(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（A）　(11)特許出願公開番号
特開2000－248338
（P2000－248338A）
(43)公開日　平成12年9月12日(2000.9.12)

(51)Int.Cl.⁷	識別記号	ＦＩ	テーマコード゛(参考)
Ｃ２２Ｃ　38/00	３０１	Ｃ２２Ｃ　38/00	３０１Ｚ
Ｃ２１Ｄ　6/00		Ｃ２１Ｄ　6/00	Ｖ
Ｃ２２Ｃ　38/14		Ｃ２２Ｃ　38/14	
38/58		38/58	

審査請求　未請求　請求項の数７　ＯＬ　（全 11 頁）

(21)出願番号　特願平11－361003
(22)出願日　平成11年12月20日(1999.12.20)
(31)優先権主張番号　特願平10－372404
(32)優先日　平成10年12月28日(1998.12.28)
(33)優先権主張国　日本（ＪＰ）

(71)出願人　000001199
株式会社神戸製鋼所
兵庫県神戸市中央区脇浜町１丁目３番18号
(72)発明者　浅井　達也
兵庫県加古川市金沢町１番地　株式会社神戸製鋼所加古川製鉄所内
(72)発明者　十代田　哲夫
兵庫県加古川市金沢町１番地　株式会社神戸製鋼所加古川製鉄所内
(74)代理人　100101395
弁理士　本田　▲龍▼雄

(54)【発明の名称】　焼入部の靭性に優れた高周波焼入用鋼板、高周波焼入強化部材およびその製造方法

(57)【要約】
【課題】　焼入性に優れ、しかも焼入部が靭性を備えた、衝撃吸収特性に優れた高周波焼入用鋼板、高周波焼入強化部材およびその製造方法を提供する。
【解決手段】　本発明の高周波焼入用鋼板は、mass%で、Ｃ：０．０５～０．２０%、Ｍｎ：０．３～２．５%、Ｐ：０．０２%以下、Ｓ：０．０２%以下、Ａｌ：０．０６%以下、Ｔｉ：０．０１５%以下、Ｎ：０．０１０%以下、Ｂ：０．０００５～０．００４０%を含み、残部Ｆｅおよび不可避的不純物よりなる。前記基本的成分のほか、さらに鋼板の特性を向上させる元素として、Ｓｉ、Ｃｒ、Ｍｏ、Ｖ、Ｗ、Ｃｕ、Ｎｉのいずれか１種以上をそれぞれ１．０%以下含有することができる。前記高周波焼入用鋼板を所定形状に成形した後、強度を向上させる部位に高周波焼入を施すことで、高周波焼入強化部材が得られる。焼入部の旧オーステナイト粒径は２０μm以下にするのがよい。

1

【特許請求の範囲】

【請求項１】　mass%で、Ｃ：０．０５～０．２０%、Ｍｎ：０．３～２．５%、Ｐ：０．０２%以下、Ｓ：０．０２%以下、Ａｌ：０．０６%以下、Ｔｉ：０．０１５%以下、Ｎ：０．０１０%以下、Ｂ：０．０００５～０．００４０%を含み、残部Ｆｅおよび不可避的不純物よりなる焼入部の靭性に優れた高周波焼入用鋼板。

【請求項２】　請求項１に記載した成分のほか、さらにＳｉ、Ｃｒ、Ｍｏ、Ｖ、Ｗ、Ｃｕ、Ｎｉのいずれか１種以上をそれぞれ１．０%以下含有する請求項１に記載した焼入部の靭性に優れた高周波焼入用鋼板。

【請求項３】　請求項１または２に記載した高周波焼入用鋼板により形成され、強度を向上させる部位に高周波焼入が施された高周波焼入強化部材。

【請求項４】　請求項１または２に記載された高周波焼入用鋼板を素板とする溶融亜鉛めっき鋼板により形成され、強度を向上させる部位に高周波焼入が施され、焼入部にめっき層が残存してなる高周波焼入強化部材。

【請求項５】　焼入部において観察される、焼入前の旧オーステナイト粒径が２０ μm 以下である請求項３または４に記載した高周波焼入強化部材。

【請求項６】　請求項１または２に記載した高周波焼入用鋼板を所定の形状に形成し、強度を向上させる部位に Ar_3 点以上、１０００℃以下の焼入温度で高周波焼入を施す高周波焼入強化部材の製造方法。

【請求項７】　請求項１または２に記載された高周波焼入用鋼板を素板とする溶融亜鉛めっき鋼板を所定の形状に形成し、強度を向上させる部位に Ar_3 点以上、１０００℃以下の焼入温度で、かつ焼入の際の加熱開始から焼入温度に到達し、その後３５０℃に冷却されるまでのヒートサイクルタイムを６０sec 以下とする高周波焼入を施す高周波焼入強化部材の製造方法。

【発明の詳細な説明】

【０００１】

【発明が属する技術分野】本発明は、自動車用部材等の加工用素材鋼板に関し、特に必要な形状に加工後、所要の部位を高周波焼入することで部材の高強度化を図ることができる鋼板、高周波焼入強化部材およびその製造方法に関する。

【０００２】

【従来の技術】薄鋼板を加工した自動車用成形部材には、自動車衝突時にその部材が完全に破壊することなく、変形することで、衝突時の衝撃エネルギーを吸収する特性が要求される場合がある。このような特性が要求される部材には、衝撃エネルギー吸収用の補強材が付設され、要求特性を満足するように設計される。例えば、自動車側面の重要な部材であるセンターピラーは、衝突時に３点曲げによる衝撃的な変形が生じるため、曲げ変形が予想される部分に補強材が使用されている。

【０００３】一方、自動車の軽量化のためには、補強材

2

を省略することが望ましい。このためには、素材鋼板として高強度鋼板を用いることが考えられる。しかし、高強度鋼板は成形性に劣るという問題がある。そこで、近年、補強材あるいは高強度鋼板を使用する代わりに、比較的強度の低い鋼板を用いて所定の形状に成形し、強度を必要とする部位に対し、成形後に高周波焼入を施して焼入強化する技術が適用されつつある。

【０００４】かかる技術を適用する場合、素材鋼板の焼入性を向上させる必要がある。鋼の焼入性を向上させる手段としてＢ添加がよく用いられる。その際、焼入性に関与するのは鋼中のフリーＢであるが、Ｂは鋼中のＮと非常に結合しやすい元素であるため、ＢがＮと結合して窒化ホウ素（ＢＮ）を生成するとＢの焼き入れ効果が消失する。このため、ＢよりＮと結合しやすいＴｉをＮ当量以上に添加し、鋼中のＮをＴｉＮとして固定し、ＮとＢとの結合を防止し、フリーＢを確保することが行われている。

【０００５】

【発明が解決しようとする課題】自動車用部材であるセンターピラーやバンパーリンフォース等は衝突時の衝撃吸収特性が重要であり、これらの部材に対して焼入強化を適用して強化を図る場合、焼入部は単に強化のために高硬度化すればよいというものではなく、衝突変形時に割れが発生せず、衝撃吸収エネルギーが大きいことが重要である。

【０００６】ところが、ＴｉによりＮを固定し、Ｂを添加した場合、焼入部に割れが発生しやすく、衝撃吸収特性が必ずしも向上しないことが判明した。その原因を調査したところ、破面に粗大なＴｉＮが存在しており、このＴｉＮが割れの発生を招いているものと推定された。ＴｉＮは鋼の溶製時に生成するために、粗大化して素材中に分散する。さらに、焼入時の加熱では分解せず、焼入後もそのまま存在する。従って、焼入部の割れを抑制し、衝撃吸収特性を向上させるにはＴｉ量を極力低減することが有効である。しかし、そうするとＴｉ量の低減に従ってＢの焼入性向上効果も期待できないようになる。

【０００７】本発明はかかる問題に鑑みなされたもので、焼入性に優れ、しかも焼入部が靭性を備えた、衝撃吸収特性に優れた高周波焼入用鋼板、高周波焼入強化部材およびその製造方法を提供するものである。

【０００８】

【課題を解決するための手段】請求項１に記載した本発明の高周波焼入用鋼板は、mass%で、Ｃ：０．０５～０．２０%、Ｍｎ：０．３～２．５%、Ｐ：０．０２%以下、Ｓ：０．０２%以下、Ａｌ：０．０６%以下、Ｔｉ：０．０１５%以下、Ｎ：０．０１０%以下、Ｂ：０．０００５～０．００４０%を含み、残部Ｆｅおよび不可避的不純物からなるものである。この鋼板によると、Ｔｉ、Ｎ、Ｂを所定量に規制したので、Ｂによる焼

入性向上作用、焼入前オーステナイト粒の成長抑制作用、結晶粒界の強化作用が相まって、高周波加熱のような短時間の加熱で、しかも焼入温度が比較的低くても、焼入効果を十分に発揮させることができ、また焼入部の靭性向上により、衝撃吸収特性を向上させることができる。

【０００９】本発明の鋼板は、以上の基本的成分のほか、請求項２に記載したように、必要に応じてＳｉ、Ｃｒ、Mo、Ｖ、W、Ｃｕ、Ｎｉのいずれか１種以上をそれぞれ１．０％以下含有することができ、これらの元素の含有により衝撃吸収特性をより向上させることができると考えられる。

【００１０】また、請求項３に記載した本発明の高周波焼入強化部材は、前記高周波焼入用鋼板により形成され、強度を向上させる部位に高周波焼入が施されたものであり、衝撃吸収特性に優れる。

【００１１】また、請求項４に記載した本発明の高周波焼入強化部材は、前記高周波焼入用鋼板を素板とする溶融亜鉛めっき鋼板により形成され、強度を向上させる部位に高周波焼入が施され、焼入部にめっき層が残存してなるものであり、衝撃吸収特性に優れ、しかも塗装性、耐食性にも優れる。前記溶融亜鉛めっき鋼板には、合金化溶融亜鉛めっき鋼板が含まれる。

【００１２】これらの高周波焼入強化部材において、請求項５に記載したように、焼入部において観察される、焼入前の旧オーステナイト粒径が２０μm 以下とすることで、静動比（引張試験において変形速度が２．０mm／sec 程度の低速変形の場合の最大応力をσＡ、変形速度が１０ｍ／sec 程度の高速変形の場合の最大応力をσＢとしたとき、静動比＝σＢ／σＡ）を向上させることができ、優れた衝撃吸収特性が得られる。

【００１３】また、請求項６に記載した本発明の高周波焼入強化部材の製造方法は、請求項１または２に記載した高周波焼入用鋼板を所定の形状に形成し、強度を向上させる部位にAr_3点以上、１０００℃以下の焼入温度で高周波焼入を施すものである。また、請求項７に記載した本発明の高周波焼入強化部材の製造方法は、請求項１または２に記載した高周波焼入用鋼板を所定の形状に形成し、強度を向上させる部位にAr_3点以上、１０００℃以下の焼入温度で、かつ焼入の際の加熱開始から焼入温度に到達し、その後３５０℃に冷却されるまでのヒートサイクルタイムを６０sec 以下とする高周波焼入を施すものである。これらの発明では、請求項１または２に記載した高周波焼入用鋼板、あるいは当該高周波焼入用鋼板を素板とする溶融亜鉛めっき鋼板（合金化溶融亜鉛めっき鋼板を含む。）を用いているので、成形容易であり、また焼入温度が１０００℃以下の比較的低温での焼き入れが可能となり、焼入部において観察される、焼入前の旧オーステナイト粒径を２０μm 以下とすることができ、衝撃吸収特性に優れる。しかも、低温焼入により、焼入後の変形も低減することができる。さらに、溶融亜鉛めっき鋼板の場合には、焼入温度が１０００℃以下と低いため、焼入の際に亜鉛めっき層が蒸発により消失することを防止することができ、引いては鉄系酸化皮膜の生成による塗装性の劣化を防止することができる。しかも、ヒートサイクルタイム（図１１参照）を６０sec 以下とするため、溶融亜鉛めっき層が焼入の際に過度な合金化、すなわちＦｅ原子が溶融亜鉛めっき層に過度に拡散することによる耐食性の劣化を防止することができる。

【００１４】

【発明の実施の形態】本発明者は、高周波焼入時の加熱温度でもＢＮが分解することに着目した。しかし、高周波加熱による焼入では加熱時間が通常の熱処理に比較して短いため、ＢＮが十分に分解して、焼入性の向上に寄与する十分なフリーＢが確保できるかが問題となる。そこで様々な、Ｔｉ、Ｎ及びＢ量の鋼を溶製して製造された鋼板の焼入性と衝撃吸収エネルギーを調査した結果、特定量のＴｉ、Ｎ、Ｂの下では、高周波加熱のような短時間の加熱でもＢによる焼入効果を十分に発揮させることができ、衝突時などの高速変形時に割れが発生せず、衝撃吸収エネルギーも高い値が得られることを知見し、本発明を完成するに至った。

【００１５】すなわち、本発明の高周波焼入用鋼板は、mass%で、Ｃ：０．０５～０．２０%、Ｍｎ：０．３～２．５%、Ｐ：０．０２%以下、Ｓ：０．０２%以下、Ａｌ：０．０６%以下、Ｔｉ：０．０１５%以下、Ｎ：０．０１０%以下、Ｂ：０．０００５～０．００４０%を含み、残部Ｆｅおよび不可避的不純物よりなるものである。

【００１６】ここで、本発明の鋼板の成分限定理由について説明する。

Ｃ：０．０５～２．０%

Ｃは焼入硬さを決定する重要な元素であるが、０．０５%未満では必要な硬さ（ビッカース硬さ（荷重１kgf ）で３００Ｈｖ以上）が得られない。このため、Ｃ量の下限を０．０５%、好ましくは０．１０%とする。一方、２．０%を超えると焼入部に遅れ破壊が生じ易くなるため、上限を２．０%、好ましくは０．１８%とする。

【００１７】Ｍｎ：０．３～２．５%

Ｍｎは焼入性を向上させる元素であり、０．３%未満では焼入性向上作用が過小となり、必要な焼入硬さを得ることが困難になる。このため、Ｍｎ量の下限を０．３%、好ましくは０．５%、より好ましくは１．０%とする。一方、Ｍｎは鋳造時にミクロ偏析しやすく、この偏析は焼入後も解消されず、靭性の低下及び遅れ破壊を促進するため上限を２．５%、好ましくは２．０%とする。

【００１８】Ｐ：０．０２%以下

ＰもＭｎ同様、ミクロ偏析する元素であり、少ないほど

よく、０．０２％を越えると著しい中心偏析（板厚中央部での偏析）を生じ、遅れ破壊を助長するため、上限を０．０２％、好ましくは０．０１５％とする。

【００１９】Ｓ：０．０２％以下

ＳはＭｎと結合してＭｎＳを生成し、鋼板の加工性を劣化させ、遅れ破壊の起点ともなるため少ないほどよく、上限を０．０２％、好ましくは０．０１５％とする。

【００２０】Ａｌ：０．０６％以下

Ａｌは脱酸材として添加されるが、０．０６％を越えるとアルミナ系の介在物が増加し、ヘゲ、スリバ等の表面欠陥が急増するため、上限を０．０６％、好ましくは０．０５％とする。

【００２１】Ｔｉ：０．０１５％以下

ＴｉはＮと優先的に結合し、ＢがＮと結合するのを抑制する作用を有するが、０．０１５％超では粗大なＴｉＮが生じるようになり、このＴｉＮは高周波加熱によっても分解せず、組織中に存在するため、後述に実施例から明らかなとおり、高速変形時に割れが発生するようになる。このため、０．０１５％以下、好ましくは０．０１２％以下、より好ましくは０．０１０％以下とする。

【００２２】Ｎ：０．０１０％以下

ＮはＢと結合して鋼中のフリーのＢ量を減少させるため少ない方がよいが、過度の減少は製鋼上の困難を伴い、製造コストを上昇させるので、好ましくは下限を０．００１０％とするのがよい。一方、０．０１０％を越えるとＢによる焼入性の改善効果が発揮できないようになるため、上限を０．０１０％、好ましくは０．００８％とする。

【００２３】Ｂ：０．０００５～０．００４０％

Ｂは焼入性を改善させ、低温でも十分な焼き入れ組織が得られるようにする重要な元素である。また、焼入温度すなわちオーステナイト化温度に加熱した際に、Ｂがオーステナイト結晶粒界に析出し、低温焼き入れが可能なことと相まって、粒成長を抑制する作用があり、焼き入れ組織の微細化を図ることができ、これによって、静動比を向上させることがきる元素である。さらにまた、前記粒界への析出は、粒界の強度を向上させるため、低温変態組織の靱性を向上させることができる元素でもある。Ｂ量が０．０００５％未満では焼き入れの際に有効なＢ量が確保できず、上記作用が過小となるため、下限を０．０００５％、好ましくは０．００１０％、より好ましくは０．００２５％とする。一方、０．００４０％を越えるとFe_2B（窒化鉄）が生成するようになり、これが高速変形時の割れの起点となって、衝撃曲げ変形時の吸収エネルギーをかえって低下させる。このため、上限を０．００４０％、好ましくは０．００３５％とする。

【００２４】本発明の鋼板は、以上の基本的成分、残部Ｆｅおよび不可避的不純物よりなるものであるが、前記基本的成分の作用効果を損なわない範囲で他の元素の含有を妨げるものではなく、さらに鋼板の特性をより向上させる元素を含有させることができる。このような元素として、Ｓｉ、Ｃｒ、Ｍｏ、Ｖ、Ｗ、Ｃｕ、Ｎｉのいずれか１種以上をそれぞれ１．０％以下含有することができる。

【００２５】これらの元素は焼入部のミクロ組織をベイナイト化して延性を向上させ、割れ発生の防止に寄与するとともに必要な焼入強度を確保することができるものであり、Ｃｕ、Ｎｉはさらに耐遅れ破壊特性の改善にも寄与する。この作用を有効に発揮させるには各々０．０５％以上の含有が好ましい。一方、過多に添加するとＳｉ、Ｃｒ、Ｍｏ、Ｖ、Ｗは化成処理性が劣化し、またＣｕ、Ｎｉは熱間割れや、スケールに起因した表面疵が生じるようになるため、上限を各々１．０％、好ましくは０．６０％とする。なお、ミクロ組織は必ずしもベイナイト単相である必要はなく、フェライトや炭化物等が含まれていてもよい。また、これらの元素は焼入性改善のための基本元素とすることはできない。その理由は、これらの元素で焼入性を改善すると、化成処理性が劣化したり、鋼板製造時に焼入が生じて、高周波焼入強化前の素材鋼板の加工性の確保が困難になるためである。

【００２６】前記高周波焼入用鋼板は、所定の成分の鋼を溶製し、常法にて熱間圧延、あるいはさらに冷間圧延を施すことにより製造される。熱延あるいは冷延後、あるいは冷延後にさらに溶融亜鉛めっきを施した鋼板組織はフェライトおよびパーライト組織となっており、高周波焼入前の引張強さは５００ＭＰａ程度以下であるため、プレス成形が容易で、所定の部材形状に容易に成形することができる。成形後、強度を向上させたい部位（部材の全領域を含む。）に高周波焼き入れを施すことにより、本発明の高周波焼入強化部材が得られる。なお、焼入後の冷却方法は、板厚に応じて、水冷、ミスト冷却、気水冷却、空冷（強制空冷を含む。）、冷却金型の接触等の適宜の方法を採ることができる。

【００２７】本発明で規定するＣ含有量を有する炭素鋼板では、通常、焼入によってマルテンサイトを得るためには、焼入前のオーステナイト粒径を大きくし、これによって焼入性を向上させておく必要があるため、焼入温度は１０００℃超とされるのであるが、本発明ではＢの焼入性向上作用により、焼入温度を比較的低温に設定することができ、１０００℃以下、好ましくは９５０℃以下、より好ましくは９００℃以下の比較的低温で行うことができる。焼入温度をこのような温度に設定することで、Ｂの粒界析出によるオーステナイト粒の成長抑制作用と相まって、焼き入れ後に観察される旧オーステナイト粒径を２０μｍ以下とすることができる。旧オーステナイト粒径を２０μｍ以下、好ましくは１５μｍ以下とすることで、焼入部の静動比を向上させることができ、引いては高周波焼入強化部材の衝撃吸収特性を向上させることができる。

【００２８】図１は、静動比と衝撃吸収エネルギーとの関係を説明するための応力歪線図であり、図中のＡは引張速度が２mm／sec 程度の低速引張の場合の応力歪線であり、Ｂは引張速度が１０ｍ／sec 程度の衝突時を想定した高速引張の応力歪線である。静動比は、Ａの最大応力σＡに対するＢの最大応力σＢの比σＢ／σＡで表される。一方、応力歪線によって囲まれた領域（応力歪線Ａについて斜線部で示した領域）は、変形時における衝撃吸収エネルギーを示す。図から明らかなように、静動比が大きいほど、高速変形時における衝撃吸収エネルギーが大きくなる。ハイテンなどの高張力鋼板では、強度が大きくなるほど静動比は１に近づく傾向があり、鋼板強度を上げるだけでは、衝撃吸収特性が有利になるとは必ずしも言えないが、本発明鋼板の場合、後述の実施例から明らかなとおり、高周波焼入により強度が向上するとともに、静動比も向上し、優れた衝撃吸収特性を備えたものとなる。

【００２９】本発明の鋼板は、冷間圧延後、溶融亜鉛めっき処理を施し、溶融亜鉛めっき鋼板とすることができる。勿論、溶融亜鉛めっき後に合金化熱処理を施して合金化溶融亜鉛めっき鋼板としてもよい。

【００３０】本発明の高周波焼入強化部材は、このような溶融亜鉛めっき鋼板を用いて、所定の形状にプレス成形し、強化すべき部位に高周波焼入を施すことによっても得られる。この場合、焼入温度が高過ぎると、焼入の際に亜鉛が蒸発し、亜鉛めっき層が消失し、さらに鋼板の表面に酸化皮膜が形成されるおそれがある。亜鉛めっき層が消失し、酸化皮膜が形成されると、部材表面を塗装する場合、塗装の下地であるりん酸塩皮膜が付着しにくくなり、引いては塗膜密着性が劣化する。本発明では、Ｂの作用により、焼入温度を低くすることができ、焼入温度を１０００℃以下、好ましくは９５０℃以下、より好ましくは９００℃以下とすることで、亜鉛めっき層の消失を防止することができ、良好な塗装密着性をも確保することができる。さらに、焼入の際の加熱開始から焼入温度に到達し、その後３５０℃に冷却されるまでのヒートサイクルタイム（図１１参照）を６０sec 以下、好ましくは３０sec 以下、より好ましくは１０sec 以下とすることにより、溶融亜鉛めっき層の過度の合金化を抑制することができるため、溶融亜鉛めっき層の耐食性の劣化を防止することができる。以下、実施例によって本発明をさらに具体的に説明するが、本発明はかかる実施例によって限定的に解釈されるものではない。

【００３１】

【実施例】〔実施例Ａ〕下記Ａ鋼、Ｂ鋼をベースとして、ベース鋼に対して種々の割合のＴｉを添加した鋼を溶製し、そのスラブを常法により熱間圧延（仕上温度８７０℃、巻取温度６５０℃）、冷間圧延（冷延率５５％、再結晶焼鈍温度７２０℃）して板厚１．６mmの冷延鋼板を製作し、図２に示す衝撃３点曲げ試験部材を製作し、衝撃３点曲げ試験により衝撃吸収エネルギーを測定した。

・Ａ鋼（mass%、残部実質的にＦｅ）

Ｃ：０．１２%、Ｍｎ：１．４９%、Ｐ：０．０１３%、Ｓ：０．００５%、Ａｌ：０．０４３%、Ｎ：０．０４１%、Ｂ：０．００２９%

・Ｂ鋼（mass%、残部実質的にＦｅ）

Ｃ、Ｍｎ、Ｐ、Ｓ、ＡｌはＡ鋼と同じ。

Ｎ：０．０３３%、Ｂ：０．００５５%

【００３２】前記試験部材１は、図２に示すように、断面がハット形の成形部材２の開口部に平板３を付設して、成形部材２のフランジ部を図のように４０mmピッチでスポット溶接したものである。図中の寸法単位はmmであり、ハット形成形部材２の上部の角部（２箇所）に施した斜線部は試験部材を組み立て後に形成した高周波焼入による焼入部を示す。焼入条件は、ヒートサイクルタイムを約５秒とし、９００℃に高周波加熱後、水冷したものであり、焼入部の組織は、マルテンサイト組織であった。

【００３３】前記衝撃３点曲げ試験は、図３に示すように、前記試験部材１をハット形成形部材２が下方になるようにして、試験部材１の両端部（荷重間隔５００mm）の対称位置に各々１００ｋｇの荷重Ｐを付加して水平に保持した状態で、試験部材１の長さ方向の中心部を曲げ治具に１０．６ｍ／sec で衝突させ、この時に生じた衝撃吸収エネルギーを測定するものである。前記衝撃吸収エネルギーは、曲げ治具１０（上部の半径＝１５０mm）より２００mm離れた位置に設けられたレーザ変位計１１によって、試験部材１と曲げ治具１０とが接触した瞬間の変位（図中２点鎖線で表示した状態）を０とし、試験部材１が折れ曲がって変形し、レーザ変位計１１によって測定される変位が７０mmになるまで曲げ治具１０に作用した荷重を測定することにより求めた。図４は、前記変位と荷重との関係を模式的に示した図であり、図中斜線で示した部分の面積が吸収エネルギー値を示す。なお、治具１０に作用した荷重は、曲げ治具１０が取り付けられたロードセル１２によって測定した。

【００３４】上記衝撃３点曲げ試験の結果を図５に示す。同図より、Ｔｉ含有量が０．０１５%超の高含有域ではＡ鋼、Ｂ鋼を用いた鋼板とも粗大なＴｉＮが生成し、衝撃３点曲げにおける吸収エネルギー値が低く、特にＢ量が本発明範囲超のＢ鋼を用いたものでは、焼入部において割れが認められた。一方、Ｔｉ含有量が特に０．０１０%以下の低含有域では本発明成分範囲のＡ鋼を用いた鋼板では発明範囲外のＢ鋼を用いた鋼板に比して非常に大きな吸収エネルギー値が得られており、優れた耐衝撃性が得られていることがわかる。

【００３５】〔実施例Ｂ〕下記表１に示した鋼を溶製し、そのスラブを同表に示す製造条件により冷延鋼板（板厚１．６mm）、合金化溶融亜鉛めっき鋼板（板厚

１．６㎜）、熱延鋼板（板厚２．０㎜）を製造し、機械的性質を測定した。その結果を表１に併せて示す。

【００３６】

【表１】

試料No	化学成分（mass %、残部：実質的にFe）									製造方法	熱延条件		冷延率 %	焼鈍温度 ℃	合金化温度 ℃	YS MPa	TS MPa	El %	備考
	C	Mn	Si	P	S	Al	N	B	Ti	その他		FDT ℃	CT ℃						
1	0.12	1.45	0.03	0.012	0.008	0.034	0.0044	0.0021	0.0050	－	冷延	870	660	55	780	－	285	457	33	P
2	0.15	1.47	0.02	0.011	0.007	0.033	0.0021	0.0022	0.0040	－	めっき	870	660	55	780	690	288	443	36	P
3	0.18	0.88	0.02	0.013	0.006	0.035	0.0032	0.0030	0.0040	－	冷延	870	660	55	780	－	285	487	35	P
4	0.08	1.44	0.01	0.010	0.005	0.045	0.0040	0.0011	0.0038	－	冷延	870	660	55	780	－	283	453	36	P
5	0.13	1.88	0.04	0.013	0.012	0.041	0.0038	0.0037	0.0030	－	めっき	870	660	55	780	690	308	520	28	P
6	0.11	1.52	0.03	0.010	0.008	0.036	0.0010	0.0005	0.0030	－	めっき	870	660	55	780	690	293	448	34	P
7	0.14	0.80	0.02	0.015	0.009	0.042	0.0020	0.0038	0.0050	－	冷延	870	660	55	780	－	275	449	33	P
8	0.16	0.88	0.02	0.015	0.005	0.048	0.0058	0.0022	0.0080	－	冷延	870	660	55	780	－	273	462	33	P
9	0.12	1.43	0.03	0.011	0.008	0.033	0.0078	0.0011	0.0050	－	めっき	870	660	55	780	690	285	455	31	P
10	0.09	2.45	0.03	0.014	0.005	0.047	0.0067	0.0005	0.0040	－	熱延	890	430	－	－	－	305	494	30	P
11	0.11	1.53	0.05	0.012	0.013	0.029	0.0120	0.0027	0.0050	－	冷延	870	660	50	800	－	267	451	35	C
12	0.12	1.51	0.04	0.001	0.011	0.024	0.0110	0.0011	0.0040	－	冷延	870	660	50	800	－	270	462	24	C
13	0.18	1.49	0.02	0.010	0.005	0.044	0.0044	0.0003	0.0040	－	冷延	870	660	50	800	－	285	478	36	C
14	0.13	2.70	0.03	0.012	0.006	0.033	0.0039	0.0025	0.0030	－	冷延	870	660	50	800	－	292	482	31	C
15	0.12	1.55	0.03	0.013	0.011	0.028	0.0033	0.0028	0.0180	－	めっき	870	660	50	800	690	274	481	32	C
16	0.09	2.01	0.02	0.016	0.015	0.031	0.0021	0.0045	0.0060	－	冷延	870	660	50	800	－	280	457	33	C
17	0.06	1.53	1.00	0.011	0.006	0.027	0.0029	0.0023	0.0040	Cr:0.60	熱延	890	350	－	－	－	362	588	28	P
18	0.09	1.51	0.02	0.012	0.009	0.033	0.0025	0.0028	0.0030	Mo:0.30	熱延	890	500	－	－	－	363	455	30	P
19	0.17	1.46	0.03	0.013	0.007	0.049	0.0035	0.0022	0.0050	Ni:1.10 Cu:1.00	冷延	870	660	60	800	－	269	476	33	P
20	0.12	1.50	0.02	0.014	0.005	0.033	0.0031	0.0029	0.0050	Cr:0.30 Mo:0.20	冷延	870	660	60	800	－	277	442	35	P

（注）備考　P：発明例、C：比較例

【００３７】また、試料鋼板から試験片を採取し、所定の領域を９００℃で高周波加熱し、同温度到達後直ちに加熱を停止し、表２に示す冷却条件により冷却することによって焼き入れ、焼入部周辺の硬さ分布を調べて焼入部の平均硬さを求めるとともにミクロ組織を調べた。また、実施例Ａと同様、衝撃３点曲げ試験部材を製作し、同部位に表２の焼入条件にて焼入を行った後、前記衝撃３点曲げ試験を行い、衝撃吸収エネルギーを測定し、また試験後の曲げ部の割れ発生状況を観察した。これらの結果を表２に示す。表中のミクロ組織は面積率で５０％以上を占める組織を示しており、残部はフェライト及び／又は残留オーステナイトである。また、試料No．１～１３、１６につき、ＮとＢとが焼入性に及ぼす影響を整理したグラフを図６に示す。図中の数字は「試料No．／焼入部の平均硬さ（Ｈｖ）」を示す。また、焼入部周辺の硬さ分布測定結果の一例を図７（試料No．１３）、図８（試料No．７）に示す。なお、図７，図８における焼入部は、図２の焼入領域（斜線領域）の中央部の点線位置に対応する。

【００３８】

【表２】

試料No.	焼入条件	焼入部平均硬さ(Hv)	焼入部主要ミクロ組織*	衝撃3点曲げ吸収エネルギー(J)	衝撃3点曲げ曲げ部割れ発生状況	備考
1	水冷	416	M	2476	なし	発明例
2	水冷	413	M	2458	なし	〃
3	水冷	427	M	2542	なし	〃
4	水冷	397	M	2363	なし	〃
5	水冷	429	M	2554	なし	〃
6	水冷	365	M	2173	なし	〃
7	水冷	369	M	2196	なし	〃
8	水冷	374	M	2226	なし	〃
9	水冷	338	M	2012	なし	〃
10	水冷	335	M	1994	なし	〃
11	水冷	281	M	1287	なし	比較例
12	水冷	287	M	1314	なし	〃
13	水冷	344	M	1575	あり	〃
14	水冷	435	M	1992.	なし	〃
15	水冷	427	M	1955	あり	〃
16	水冷	396	M	1813	あり	〃
17	空冷	433	B	2577	なし	発明例
18	空冷	407	B	2423	なし	〃
19	水冷	412	B	2452	なし	〃
20	空冷	425	B	2530	なし	〃

(注) * 面積率50%以上を占めるミクロ組織を表示
M：マルテンサイト、B：ベイナイト

【0039】表2および図6から明らかなとおり、Nが0．010%超の試料No．11及び12では、焼入部の硬さが300Hvを下回っており、十分な焼入硬さが得られず、強化が不十分であることがわかる。また、これらの試料は吸収エネルギーも低い。これは、N量が過多のため、高周波加熱の際のBNの分解が不十分となるためと推測される。

【0040】また、表2および図6より、Bが0．004%超の試料No．16、Bが0．0005%未満の試料No．13では、焼入部の硬さは良好であるが、吸収エネルギーが低く、曲げ部に割れが発生した。これは、試料No．16では、B量が過多であるため粒界にFe_2Bが析出したためであり、一方試料No．13ではB量が少な過ぎて十分な焼入性が得られなかったためである。因みに、試料No．13の硬さ分布を見ると、図7から明らかなとおり、平均硬さは344Hvと良好であるが、焼入部の硬さにむらがあり、引いては強度にむらが生じて、強度の低い部分に変形が集中するために割れが生じたものと推測される。なお、図8に発明例の試料No．7＊の硬さ分布を示すが、この例では焼入部の平均硬さは369Hvで、しかも焼入部における硬さも均一である。

【0041】また、表2より、基本成分のほかに特性向上元素を添加した試料No．17～20（発明例）では、ミクロ組織がベイナイト主体となっているため、吸収エネルギーの一層の向上が認められる。

【0042】〔実施例C〕下記表3に示した鋼を溶製し、そのスラブを熱間圧延（仕上温度860℃、巻取温度550℃）、冷間圧延（冷延率60%、再結晶焼鈍温度700℃）にて冷延鋼板（板厚1．6mm）を製造した。この冷延鋼板から採取した供試鋼板を用いて、図9に示すように、鋼板ガイド21から供試鋼板Wを対向配置された高周波コイル22、冷却ノズル23，23の間に送り込み、表4に示す焼入条件にて供試鋼板の全面に高周波焼入を施した。ヒートサイクルタイムは約3秒であり、焼入温度到達後、速やかに冷却した。

【0043】
【表3】

鋼種No.	化学成分（mass %、残部：実質的にFe）											備考
	C	Si	Mn	P	S	Al	N	B	Ti	Cr	Mo	
A	0.16	<0.02	1.60	0.010	0.005	0.035	0.003	0.0030	<0.01	<0.02	<0.02	発明鋼
B	0.13	<0.02	1.52	0.008	0.007	0.030	0.035	0.0025	<0.01	<0.02	<0.02	〃
C	0.10	<0.02	1.05	0.012	0.007	0.027	0.033	0.0033	<0.01	0.30	<0.02	〃
D	0.13	<0.02	0.85	0.010	0.006	0.033	0.004	<0.0003	<0.01	<0.02	<0.02	比較鋼
E	0.13	<0.02	2.00	0.011	0.005	0.028	0.028	<0.0003	<0.01	<0.02	<0.02	〃
F	0.16	<0.02	1.50	0.010	0.006	0.031	0.003	0.0028	<0.01	0.50	0.30	発明鋼

【0044】得られた高周波焼入強化鋼板から引張試験片を採取し、低速引張（引張速度2㎜／sec ）の下で最大応力（静的ＴＳ）を求めるとともに、高速引張（引張速度１０ｍ／sec ）の下で最大応力（動的ＴＳ）を求め、静動比を求めた。なお、応力は試験片の両面に歪ゲージを付設し、これによって測定された平均荷重から算出した。また、高周波焼入強化鋼板から組織観察片を採取し、焼入前の旧オーステナイト結晶粒界の痕跡を顕微鏡観察し、その平均結晶粒径を測定した。これらの調査結果を表４に併せて示す。また、静動比と旧オーステナイト粒径との関係を整理したグラフを図１０に示す。なお、表４には、焼入前の引張強度も併せて示した。

【0045】

【表４】

試料No.	鋼種No.	焼入前TS Mpa	焼入温度℃	冷却条件	静的TS Mpa	動的TS Mpa	静動比	旧オーステナイト粒径 μm	備考
31	B	466	900	水冷	1250	1413	1.13	20	発明鋼
32	B	〃	800	〃	1050	1155	1.10	10	〃
33	F	456	900	空冷	1025	1148	1.12	12	〃
34	A	460	900	〃	1320	1412	1.09	18	〃
35	A	〃	800	〃	1013	1124	1.11	12	〃
36	C	455	900	〃	1033	1126	1.09	15	〃
37	C	〃	800	〃	981	1079	1.10	11	〃
38	D	444	1000	水冷	1350	1391	1.03	83	比較鋼
39	D	〃	900	〃	1180	1239	1.04	45	〃
40	D	〃	800	〃	965	1033	1.03	26	〃
41	E	480	900	〃	1350	1391	1.03	34	〃
42	E	〃	800	空冷	1250	1313	1.05	28	〃

【0046】表４および図１０より、発明鋼を用いた試料No．３１～３７は、旧オーステナイト粒径が２０μｍ以下であり、静動比が比較例に比して高い値であり、衝撃吸収特性に優れていることが推察された。

【0047】さらに、表３の鋼種Ａ～Ｃ（発明鋼）を用いて、板厚１．６㎜に冷間圧延後、さらに連続溶融亜鉛めっきラインにて両面で４５ｇ／ｍ² の溶融亜鉛めっきを施し、実施例Ａと同様にして衝撃３点曲げ試験部材１を製作し、同部位に下記表５の条件にて高周波焼入を行った。ヒートサイクルタイムは約３秒であり、焼入温度到達後、速やかに冷却した。

【0048】高周波焼入後、試験部材の焼入部における亜鉛めっき層の有無を観察した。さらに、下記の要領で塗膜剥離試験を行い、焼入部に形成した塗膜の剥離の有無を調べた。試験部材を脱脂し、水洗乾燥後、４０℃で２分間リン酸塩処理液に浸漬し、焼入部にリン酸塩皮膜を形成し、水洗乾燥後、膜厚約２０μｍの塗膜を電着塗装により形成した。乾燥後、１０×１０㎟ の試験領域に１㎜ピッチのマス目をカッターナイフで入れ、４０℃で２４０ｈｒｓ純水中に浸漬し、乾燥後、試験領域に接着テープを張り付け、引き剥がして、１㎜角のマス目中において塗膜が５０％以上剥離したものが１箇所でもあれば剥離あり（×）と判定した。

【0049】

【表５】

試料No.	鋼種No.	焼入温度℃	冷却条件	焼入部硬さ	めっき層 残存：○ 消失：×	塗膜剥離 なし：○ あり：×
51	B	800	〃	352	○	○
52	〃	900	〃	383	○	○
53	〃	1000	〃	413	○	○
54	A	800	空冷	310	○	○
55	〃	900	〃	337	○	○
56	〃	<u>1100</u>	〃	343	×	×
57	C	800	〃	302	○	○
58	〃	900	〃	321	○	○
59	〃	<u>1100</u>	〃	373	×	×

【0050】表５より、発明鋼を用い、焼入温度を１０００℃以下として高周波焼入を行ったもの（試料No．５１～５５，５７，５８）では、溶融亜鉛めっき層が残存し、塗膜の密着性にも優れることが確かめられた。

【0051】〔実施例Ｄ〕下記組成の鋼を溶製し、その連鋳スラブを板厚４．０㎜まで熱間圧延（仕上温度８７０℃、巻取温度６６０℃）し、板厚２．０㎜まで冷間圧延（冷延率５０％）し、連続焼鈍溶融亜鉛めっきラインにて７２０℃で再結晶焼鈍温度を行った後、４６０℃にて溶融亜鉛めっき（めっき量：両面で４５ｇ／ｍ² ）を施し、引き続いて６９０℃×７sec にて合金化処理を施した。得られた合金化溶融亜鉛めっき鋼板から供試鋼板（㎜で２．０ｔ×４０ｗ×３００Ｌ）を採取し、これに図９の高周波焼入装置を用いて焼き入れした。

・鋼板成分（mass%、残部実質的にＦｅ）

Ｃ：０．１３％、Ｍｎ：１．９８％、Ｐ：０．０１３％、Ｓ：０．０１２％、Ａｌ：０．０４１％、Ｔｉ<

０．０１％、Ｎ：０．００４％、Ｂ：０．００３７％

【００５２】ヒートサイクルタイムが３sec 程度になるように、鋼板の送り速度を調整し、種々の焼入温度にて焼き入れ後、水冷した供試鋼板について、めっき層の有無、およびめっき層中のＦｅ含有量を調べた。焼入温度とＦｅ含有量との関係を整理したグラフを図１２に示す。図１２より、焼入温度が１０００℃以下ではめっき層が残存することが確認された。また、めっき層中のＦｅ量も２５％程度以下であることが確認された。

【００５３】次に、焼入温度を７００℃、８００℃、９００℃、１０００℃とし、加熱後の冷却速度を調整して種々のヒートサイクルタイムの下で高周波焼入を行った。得られた鋼板のめっき層におけるＦｅ含有量を調べ、ヒートサイクルタイムとＦｅ含有量との関係を整理したグラフを図１３に示す。図１３より、ヒートサイクルタイムが６０sec 以下では、めっき層中のＦｅが３５％程度以下に止まっていることが確認された。

【００５４】さらに、種々のヒートサイクルタイムで高周波焼入を行った前記供試鋼板から腐食試験片（㎜で２．０ｔ×７０ｗ×１５０Ｌ）を採取し、腐食試験を行った。腐食試験は、ＪＡＳＯ自動車材料腐食方法に従い、下記の工程を１サイクルとして、１７０サイクル後の最大穴あき深さを測定することによって実施された。その結果を図１４に示す。

・１サイクル工程

①塩水（３５℃、濃度５％）噴霧：８ｈｒ

②乾燥（６０℃、相対湿度３０％）：４ｈｒ

③湿潤（５０℃、相対湿度９０％）暴露：２ｈｒ

図１４より、めっき層中のＦｅ量を３５％以下であれば、最大穴あき深さが５００μm 程度以下であり、２５％以下であれば２００μm 程度に止まっており、実用上問題のない耐食性を備えたいることが確認された。

【発明の効果】本発明によれば、Ｔｉ、Ｎ、Ｂを特定の範囲に規制したので、高周波加熱の際にＢＮの分解によ＊って生じたフリーＢにより焼入性が向上し、また焼入の際にオーステナイト粒の成長を防止するとともに粒界を強化するので、焼入部の機械的性質が均一になり、強度のみならず靭性に優れ、静動比が向上し、優れた耐衝撃性が得られる。

【図面の簡単な説明】

【図１】低速変形時Ａと高速変形時Ｂにおける応力歪線図を示す。

【図２】衝撃３点曲げ試験に使用した試験部材の斜視図である。

【図３】衝撃３点曲げ試験要領説明図である。

【図４】衝撃３点曲げ試験結果を模式的に示す変位－荷重線図である。

【図５】実施例Ａにかかるａｉ量と衝撃３点曲げ吸収エネルギーとの関係を示すグラフである。

【図６】実施例ＢにかかるＮ量およびＢ量が焼入部の硬さへ及ぼす影響を示すグラフである。

【図７】実施例Ｂの試料No．１３の焼入部付近の硬さ分布を示すグラフである。

【図８】実施例Ｂの試料No．７の焼入部付近の硬さ分布を示すグラフである。

【図９】実施例Ｃにおける鋼板の焼入要領を示す概念図である。

【図１０】実施例Ｃにおける静動比と旧オーステナイト粒径との関係を示す図である。

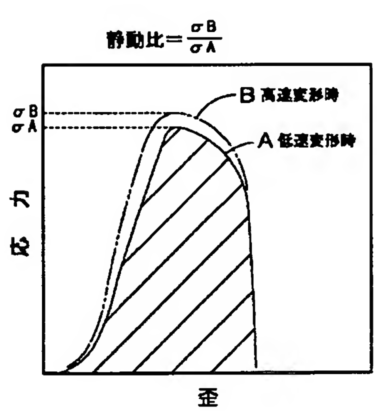
【図１１】高周波焼入におけるヒートサイクルタイムの説明図である。

【図１２】実施例Ｄにおける焼入温度とめっき層中のＦｅ含有量との関係を示すグラフである。

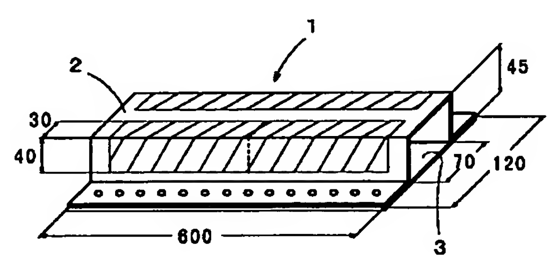
【図１３】実施例Ｄにおけるヒートサイクルタイムとめっき層中のＦｅ含有量との関係を示すグラフである。

【図１４】実施例Ｄにおけるめっき層中のＦｅ含有量と腐食試験における最大穴あき深さとの関係を示すグラフである。

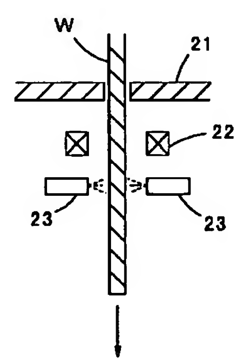
【図１】



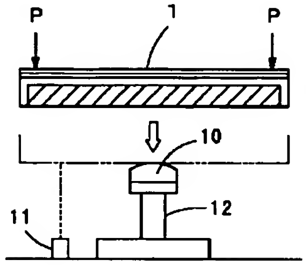
【図２】



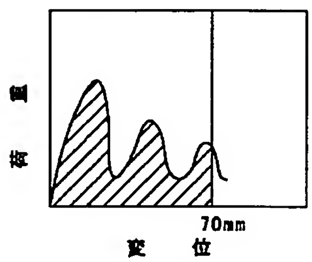
【図９】



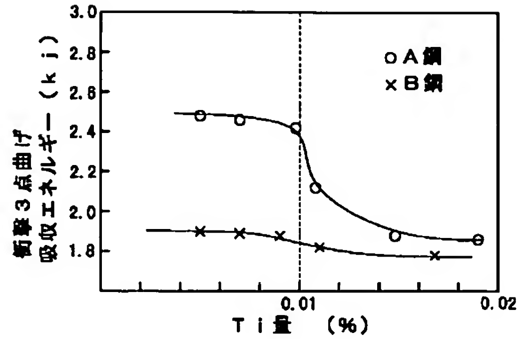
【図３】



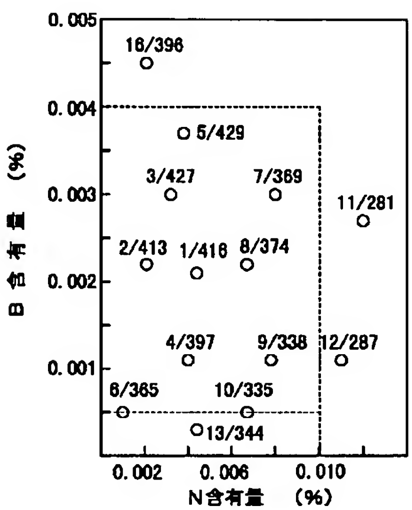
【図４】



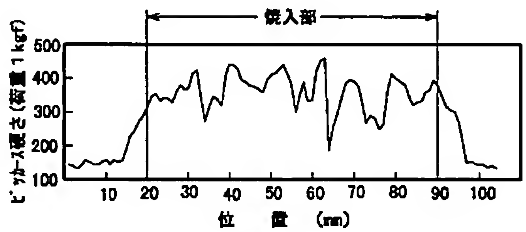
【図５】



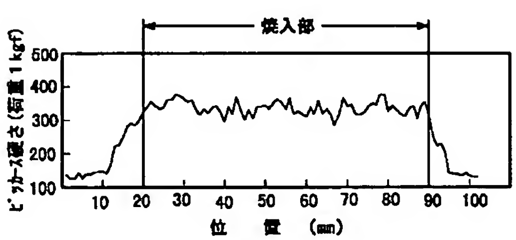
【図６】



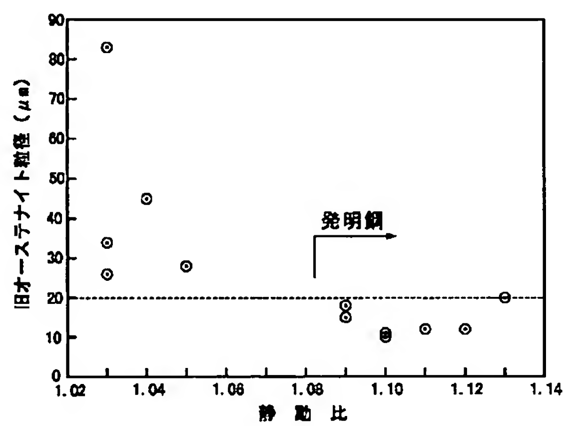
【図７】



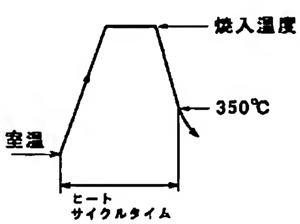
【図８】



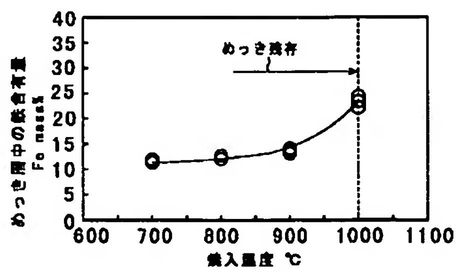
【図１０】



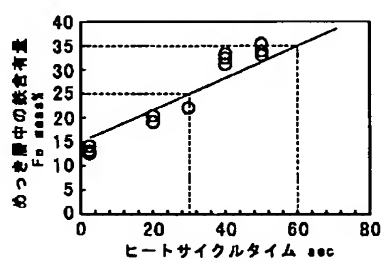
【図１１】



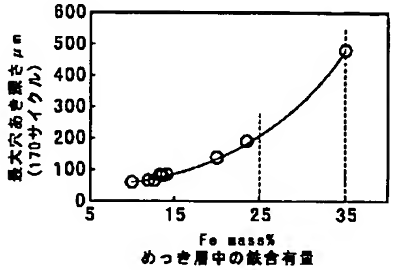
【図１２】



【図１３】



【図１４】

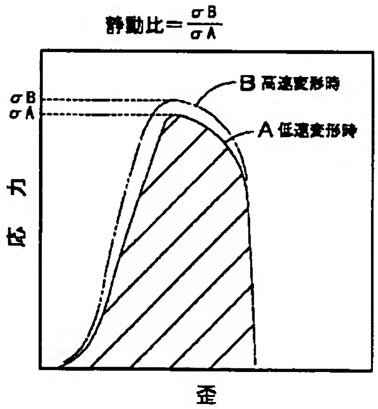

最大穴あき深さμm
(170サイクル)
600
500
400
300
200
100
0
5
15
25
35
Fe mass%
めっき層中の鉄含有量

CLAIMS

[Claim(s)]
[Claim 1] The steel plate for high-frequency induction hardening excellent in the toughness of the quenching section which consists of the remainder Fe and an unescapable impurity at mass% including less than [aluminum:0.06%], less than [Ti:0.015%], N:0.010% or less, and B:0.0005 - 0.0040% C:0.05 - 0.20%, Mn:0.3-2.5%, P:0.02% or less, and S:0.02% or less.
[Claim 2] The steel plate for high-frequency induction hardening which was further excellent in the toughness of the quenching section indicated to claim 1 which contains 1.0% or less, respectively besides the component indicated to claim 1 in any one or more sorts of Si, Cr, Mo, V, W, Cu, and nickel.
[Claim 3] The high-frequency-induction-hardening consolidation member by which high-frequency induction hardening was given to the part which is formed with the steel plate for high-frequency induction hardening indicated to claims 1 or 2, and raises reinforcement.
[Claim 4] The high-frequency-induction-hardening consolidation member to which it is formed by the hot-dip zinc-coated carbon steel sheet which makes a blank the steel plate for high-frequency induction hardening indicated by claims 1 or 2, high-frequency induction hardening is given to the part which raises reinforcement, and a plating layer comes to remain in the quenching section.
[Claim 5] The old austenite particle size before quenching observed in the quenching section is 20 micrometers. High-frequency-induction-hardening consolidation member indicated to claims 3 or 4 which are the followings.
[Claim 6] The manufacture approach of a high-frequency-induction-hardening consolidation member of giving high-frequency induction hardening to the part which forms in a predetermined configuration the steel plate for high-frequency induction hardening indicated to claims 1 or 2, and raises reinforcement with Ar of three or more points, and the hardening temperature of 1000 degrees C or less.
[Claim 7] They are 60sec(s) about a thermo-cycle time until it forms in a predetermined configuration the hot-dip zinc-coated carbon steel sheet which makes a blank the steel plate for high-frequency induction hardening indicated by claims 1 or 2, and is 1000 degrees C or less in three or more Ar(s) and hardening temperature, and it arrives at the part which raises reinforcement from the heating initiation in the case of quenching at hardening temperature and it is cooled by 350 degrees C after that. The manufacture approach of a high-frequency-induction-hardening consolidation member of giving high-frequency induction hardening made into the following.

[Translation done.]

Drawing selection drawing 1



[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to the steel plate which can attain high intensity-ization of a member by carrying out high-frequency induction hardening of the necessary part, a high-frequency-induction-hardening consolidation member, and its manufacture approach after processing a required configuration especially about raw material steel plates for processing, such as a member for automobiles.
[0002]
[Description of the Prior Art] The property which absorbs the striking energy at the time of a collision may be required of the shaping member for automobiles which processed sheet steel by deforming, without the member breaking thoroughly at the time of an automobile collision. The reinforcing materials for striking-energy absorption are attached to the member as which such a property is required, and it is designed so that demand characteristics may be satisfied. For example, since the shocking deformation by three-point bending produces the center pillar which is the important member of an automobile side face at the time of a collision, reinforcing materials are used for the part bending deformation is expected to be.
[0003] On the other hand, for lightweight-izing of an automobile, it is desirable to omit reinforcing materials. For that, it is possible to use a high-strength steel plate as a raw material steel plate. However, a high-strength steel plate has the problem of being inferior to a moldability. Then, instead of using reinforcing materials or a high-strength steel plate in recent years, a steel plate with comparatively low reinforcement is used, it fabricates in a predetermined configuration, and the technique which gives high-frequency induction hardening and carries out a quenching consolidation after shaping is being applied to the part which needs reinforcement.
[0004] When applying this technique, it is necessary to raise the hardenability of a raw material steel plate. B addition is well used as a means which raises the hardenability of steel. Although free B in steel participates in hardenability in that case, since B is an element which is very easy to combine with N in steel, if B combines with N and generates boron nitride (BN), the quenching effectiveness of B will disappear. For this reason, adding Ti which is easy to combine with N more than N equivalent, fixing N in steel as TiN, preventing association with N and B, and securing free B from B is performed.
[0005]
[Problem(s) to be Solved by the Invention] The impact-absorbing property at the time of a collision is important for a center pillar, a bumper phosphorus force, etc. which are a member for automobiles, when attaining a consolidation with the application of a quenching consolidation to these members, it does not say that what is necessary is just to form a high degree of hardness only for a consolidation, and a crack does not occur at the time of collision deformation, but it is important for the quenching section that impact absorbed energy is large.
[0006] However, when N was fixed by Ti and B was added, it was easy to generate a crack in the quenching section, and it became clear that an impact-absorbing property did not necessarily improve. When that cause was investigated, big and rough TiN existed in the fracture surface,

and that from which this TiN has caused generating of a crack was presumed. In order to generate at the time of the ingot of steel, TiN is made big and rough and distributed in a raw material. Furthermore, in heating at the time of quenching, it does not decompose but after quenching exists as it is. Therefore, it is effective to reduce the amount of Ti as much as possible to control the crack of the quenching section and raise an impact-absorbing property. However, if it does so, the improvement effectiveness in hardenability of B can also be expected no longer according to reduction of the amount of Ti.
[0007] This invention offers the steel plate for high-frequency induction hardening which was made in view of this problem, was excellent in hardenability, and was excellent in the impact-absorbing property which the quenching section moreover equipped with toughness, a high-frequency-induction-hardening consolidation member, and its manufacture approach.
[0008]
[Means for Solving the Problem] The steel plate for high-frequency induction hardening of this invention indicated to claim 1 is mass%, and consists of the remainder Fe and an unescapable impurity including less than [aluminum:0.06%], less than [Ti:0.015%], N:0.010% or less, and B:0.0005 - 0.0040% C:0.05 - 0.20%, Mn:0.3-2.5%, P:0.02% or less, and S:0.02% or less. Since Ti, N, and B were regulated to the specified quantity according to this steel plate, the improvement operation in hardenability by B, front [quenching] austenite grain growth depressant action, and the potentiation of the grain boundary are heating of a short time like high-frequency heating conjointly, moreover, even if hardening temperature is comparatively low, the quenching effectiveness can fully be demonstrated and an impact-absorbing property can be raised by improvement in toughness of the quenching section.
[0009] It is thought that the steel plate of this invention can contain any one or more sorts of Si, Cr, Mo, V, W, Cu, and nickel 1.0% or less if needed, respectively, and can raise an impact-absorbing property more by content of these elements as indicated to claim 2 besides the above fundamental component.
[0010] Moreover, it is formed with said steel plate for high-frequency induction hardening, high-frequency induction hardening is given to the part which raises reinforcement, and the high-frequency-induction-hardening consolidation member of this invention indicated to claim 3 is excellent in an impact-absorbing property.
[0011] It is formed by the hot-dip zinc-coated carbon steel sheet which makes a blank said steel plate for high-frequency induction hardening, and high-frequency induction hardening is given to the part which raises reinforcement, a plating layer comes to remain in the quenching section, and the high-frequency-induction-hardening consolidation member of this invention indicated to claim 4 is excellent in an impact-absorbing property, and, moreover, excellent also in paintwork and corrosion resistance. An alloying hot-dip zinc-coated carbon steel sheet is contained in said hot-dip zinc-coated carbon steel sheet.
[0012] The old austenite particle size before quenching observed in the quenching section in these high-frequency-induction-hardening consolidation members as indicated to claim 5 is 20 micrometers. By considering as the following A static-dynamic ratio (when the maximum stress in the case of being the high-speed deformation sigmaA and whose deformation velocity are 10 m/sec extent about the maximum stress in the case of being the low-speed deformation whose deformation velocity is 2.0 mm/sec extent is set to sigmaB in a tension test, it is static-dynamic ratio =sigmaB/sigmaA) can be raised, and the outstanding impact-absorbing property is acquired.

[0013] Moreover, the manufacture approach of the high-frequency-induction-hardening consolidation member of this invention indicated to claim 6 forms in a predetermined configuration the steel plate for high-frequency induction hardening indicated to claims 1 or 2, and gives high-frequency induction hardening to the part which raises reinforcement with Ar of three or more points, and the hardening temperature of 1000 degrees C or less. Moreover, the manufacture approaches of the high-frequency-induction-hardening consolidation member of this invention indicated to claim 7 are 60sec(s) about a thermo-cycle time until it forms in a predetermined configuration the steel plate for high-frequency induction hardening indicated to claims 1 or 2, and is 1000 degrees C or less in three or more Ar(s) and hardening temperature,

and it arrives at the part which raises reinforcement from the heating initiation in the case of quenching at hardening temperature and it is cooled by 350 degrees C after that. High-frequency induction hardening made into the following is given. since the hot-dip zinc-coated carbon steel sheet (an alloying hot-dip zinc-coated carbon steel sheet is included.) which makes a blank the steel plate for high-frequency induction hardening indicated to claims 1 or 2 or the steel plate for high-frequency induction hardening concerned in these invention is used — shaping — easy — moreover, hardening temperature — the old austenite particle size before quenching of 1000 degrees C or less which quenching of at low temperature is attained comparatively, and is observed in the quenching section — 20 micrometers It can consider as the following and excels in an impact-absorbing property. And the deformation after quenching can also be reduced with low-temperature quenching. Furthermore, in the case of a hot-dip zinc-coated carbon steel sheet, since hardening temperature is as low as 1000 degrees C or less, if it can prevent that a galvanization layer disappears by evaporation and lengthens in case it is quenching, degradation of the paintwork by generation of an iron system oxide film can be prevented. And they are 60sec(s) about a thermo-cycle time (refer to drawing 11). Since it considers as the following, in case a hot-dip-zincing layer is quenching, too much alloying, i.e., corrosion resistance degradation by Fe atom being spread too much in a hot-dip-zincing layer, can be prevented.
[0014]
[Embodiment of the Invention] this invention person noted that BN decomposed also whenever [stoving temperature / at the time of high-frequency induction hardening]. However, in quenching by high-frequency heating, whether as compared with heat treatment usual in heating time, sufficient free B which BN fully decomposes and contributes to improvement in hardenability since it is short is securable poses a problem. As a result of investigating the hardenability and impact absorbed energy of a steel plate which ingoted the steel of various Ti and N, and the amount of B, and were manufactured, so, under Ti, N, and B of the amount of specification The quenching effectiveness by B could fully be demonstrated also with heating of a short time like high-frequency heating, and a crack did not occur at the time of the high-speed deformation at the time of a collision etc., but the knowledge of a value also with high impact absorbed energy being acquired is carried out, and it came to complete this invention.
[0015] That is, the steel plate for high-frequency induction hardening of this invention is mass%, and consists of the remainder Fe and an unescapable impurity including less than [aluminum:0.06%], less than [Ti:0.015%], N:0.010% or less, and B:0.0005 - 0.0040% C:0.05 - 0.20%, Mn:0.3-2.5%, P:0.02% or less, and S:0.02% or less.
[0016] Here, the reason for component definition of the steel plate of this invention is explained. Although it is the important element with which C:0.05 - 2.0%C determines quenching hardness, at less than 0.05%, required hardness (they are 300 or more Hvs at Vickers hardness number (load 1kgf)) is not obtained. For this reason, the minimum of the amount of C is preferably made into 0.10% 0.05%. On the other hand, since it will become easy to produce delayed fracture in the quenching section if it exceeds 2.0%, an upper limit is preferably made into 0.18% 2.0%.
[0017] Mn: It is the element which raises hardenability 0.3 to 2.5% as for Mn, and at less than 0.3%, the improvement operation in hardenability becomes [too little], and it becomes difficult to obtain required quenching hardness. For this reason, the minimum of the amount of Mn is more preferably made into 1.0% 0.5% 0.3%. On the other hand, it is easy to carry out the microsegregation of Mn at the time of casting, and after quenching is not canceled, but this segregation makes an upper limit 2.0% preferably 2.5% in order to promote lowering and delayed fracture of toughness.
[0018] In order for P:0.02%or less P as well as Mn to be the element which carries out microsegregation, to produce remarkable main segregation (segregation in a board thickness center section) if it is so good that it is few and 0.02% is exceeded, and to promote delayed fracture, an upper limit is preferably made into 0.015% 0.02%.
[0019] It is so good that there is since S:0.02%or less S combines with Mn, generates MnS, degrades the workability of a steel plate and also becomes the origin of delayed fracture, and makes an upper limit 0.015% preferably 0.02%. [little]
[0020] aluminum: Although aluminum is added as deoxidation material 0.06% or less, since the

inclusion of an alumina system will increase and surface discontinuity, such as HEGE and sliver, will increase rapidly if 0.06% is exceeded, make an upper limit into 0.05% preferably 0.06%.
[0021] Since TiN big and rough in 0.015% ** comes to arise although it has the operation which controls that combine Ti:0.015%or less Ti with an N and precedence target, and B combines with N, high-frequency heating does not decompose this TiN, either but it exists during an organization, a crack comes to occur at the time of high-speed deformation a passage clear [to the after-mentioned] from an example. For this reason, it may be 0.010% or less more preferably 0.012% or less 0.015% or less.
[0022] In order for N to combine with B N:0.010% or less and to decrease the free amount of B in steel, little direction is good, but since too much reduction raises a manufacturing cost with the difficulty on steel manufacture, it is good to make a minimum into 0.0010% preferably. On the other hand, since the improvement effect of the hardenability by B can be demonstrated no longer if 0.010% is exceeded, an upper limit is preferably made into 0.008% 0.010%.
[0023] B:0.0005 - 0.0040%B is an important element with which hardenability is made to improve and quenching organization sufficient also at low temperature is obtained. Moreover, when it heats to hardening temperature, i.e., austenitizing temperature, it is the element which B depositing in the austenite grain boundary, and there being low-temperature quenching being possible and an operation which controls grain growth conjointly, being able to attain detailed-ization of a quenching organization, and raising a static-dynamic ratio by this cuts. The deposit to said grain boundary is also the element which can raise the toughness of a low-temperature transformation organization further again in order to raise the reinforcement of a grain boundary. Since the amount [with the effective amount of B] of B in the case of quenching at less than 0.0005% cannot be secured but the above-mentioned operation becomes [too little], a minimum is more preferably made into 0.0025% 0.0010% 0.0005%. On the other hand, it is Fe2 B when 0.0040% is exceeded. (nitriding iron) It comes to generate, and this serves as an origin of the crack at the time of high-speed deformation, and reduces the absorbed energy at the time of impact bending deformation on the contrary. For this reason, an upper limit is preferably made into 0.0035% 0.0040%.
[0024] Although the steel plate of this invention consists of the above fundamental component, Remainder Fe, and unescapable impurity, content of other elements cannot be barred in the range which does not spoil the operation effectiveness of said fundamental component, and the element which raises the property of a steel plate more further can be made to contain. As such an element, any one or more sorts of Si, Cr, Mo, V, W, Cu, and nickel can be contained 1.0% or less, respectively.
[0025] These elements bainite-ize the microstructure of the quenching section, and raise ductility, while contributing to prevention of crack generating, required quenching reinforcement can be secured, and Cu and nickel are further contributed also to an improvement of a delayed fracture-proof property. For demonstrating this operation effectively, 0.05% or more of content is respectively desirable. If it adds too much, in order, as for Si, Cr, Mo, V, and W, for chemical conversion nature to deteriorate and for hot tearing and the surface crack resulting from a scale to produce Cu and nickel on the other hand, an upper limit is respectively made into 0.60% preferably 1.0%. In addition, a microstructure does not necessarily need to be bainite single phase and a ferrite, carbide, etc. may be contained. Moreover, these elements cannot be used as the basic element for a hardenability improvement. The reason is because chemical conversion nature deteriorates, or quenching arises at the time of steel plate manufacture and reservation of the workability of the raw material steel plate before a high-frequency-induction-hardening consolidation becomes difficult, when hardenability is improved by these elements.
[0026] Said steel plate for high-frequency induction hardening ingots the steel of a predetermined component, and is manufactured hot rolling or by cold-rolling further with a conventional method. The steel plate organization which gave hot dip zincing further after hot-rolling, cold-rolling, or cold-rolling is a ferrite and a pearlite organization, since the tensile strength in front of high-frequency induction hardening is below 500MPa extent, it is easy press forming and it can fabricate it easily in a predetermined member configuration. The high-frequency-induction-hardening consolidation member of this invention is obtained after shaping

by performing RF quenching to the part (all the fields of a member being included.) whose reinforcement wants to improve. In addition, the cooling approach after quenching can take proper approaches, such as contact of water cooling, Myst cooling, air-water cooling, air cooling (forced-air cooling is included.), and cooling metal mold, according to board thickness.
[0027] Although hardening temperature is 1000-degree-C super-**(ed) in the carbon steel plate which has C content specified by this invention in order to usually enlarge austenite particle size before quenching in order to obtain martensite with quenching, and to raise hardenability by this this invention — the improvement operation in hardenability of B — hardening temperature — comparatively — low temperature — it can set up — 1000 degrees C or less — desirable — 950 degrees C or less — more — desirable — 900 degrees C or less — it can carry out at low temperature comparatively. It is 20 micrometers about the old austenite particle size conjointly observed after quenching by setting hardening temperature as such temperature with the austenite grain growth depressant action by the grain boundary deposit of B. It can consider as the following. It is 20 micrometers about the old austenite particle size. It is 15 micrometers preferably hereafter. If the static-dynamic ratio of the quenching section can be raised and is lengthened by considering as the following, the impact-absorbing property of a high-frequency-induction-hardening consolidation member can be raised.
[0028] Drawing 1 is a stress distorted diagram for explaining the relation between a static-dynamic ratio and impact absorbed energy, and, for A in drawing, speeds of testing are 2 mm/sec. It is stress **** in the case of being low-speed **** which is extent, and, for B, speeds of testing are 10 m/sec. It is stress **** of high-speed **** supposing the time of the collision which is extent. the ratio of maximum stress sigmaB of B [as opposed to maximum stress sigma/ of A / A in a static-dynamic ratio] — it is expressed with sigma B/sigma A. On the other hand, the field (field shown in the slash section about stress ****A) surrounded by stress **** shows the impact absorbed energy at the time of deformation. The impact absorbed energy at the time of high-speed deformation becomes large, so that from drawing and a static-dynamic ratio is large. It becomes the thing equipped with the impact-absorbing property which the impact-absorbing static-dynamic ratio also improved and was excellent while reinforcement improved by high-frequency induction hardening the passage clear from the below-mentioned example in the case of this invention steel plate, although it could not necessarily say that yes, an impact-absorbing property became advantageous only by a static-dynamic ratio tending to approach 1, so that reinforcement becomes large with a high-tensile-steel plate, such as a ten, and raising steel plate reinforcement.
[0029] The steel plate of this invention can perform hot-dip-zincing processing after cold rolling, and can use it as a hot-dip zinc-coated carbon steel sheet. Of course, alloying heat treatment is performed after hot dip zincing, and it is good for it also as an alloying hot-dip zinc-coated carbon steel sheet.
[0030] The high-frequency-induction-hardening consolidation member of this invention is obtained also by carrying out press forming to a predetermined configuration, and giving high-frequency induction hardening to the part which should be strengthened using such a hot-dip zinc-coated carbon steel sheet. In this case, when hardening temperature is too high, in case it is quenching, zinc evaporates, a galvanization layer disappears, and there is a possibility that an oxide film may be further formed on the surface of a steel plate. If a galvanization layer disappears and an oxide film is formed, when painting a member front face, if the phosphoric acid salt coat which is the substrate of paint stops being able to adhere easily and lengthens, paint film adhesion deteriorates. In this invention, disappearance of a galvanization layer can be prevented according to an operation of B by being able to make hardening temperature low and making more preferably 1000 degrees C or less of 950 degrees C or less of hardening temperature into 900 degrees C or less, and good paint adhesion can also be secured. Furthermore, they are 60sec(s) about a thermo-cycle time (refer to drawing 11) until it reaches hardening temperature from the heating initiation in the case of quenching and is cooled by 350 degrees C after that. They are 30sec(s) preferably hereafter. They are 10sec(s) more preferably hereafter. Since too much alloying of a hot-dip-zincing layer can be controlled by considering as the following, corrosion resistance degradation of a hot-dip-zincing layer can be prevented.

Hereafter, although an example explains this invention still more concretely, this invention is not restrictively interpreted according to this example.
[0031]
[Example] [Example A] The steel which added Ti of various rates to base steel is ingoted by using following A steel and B steel as the base. The slab is hot-rolled with a conventional method (finishing temperature of 870 degrees C, winding temperature of 650 degrees C). It cold-rolled (the rate of cold-rolling of 55%, recrystallization annealing temperature of 720 degrees C), cold rolled sheet steel of 1.6mm of board thickness was manufactured, the three impacts bending test member shown in drawing 2 was manufactured, and impact absorbed energy was measured by the three impacts bending test.
- A steel (mass%, the remainder substantially Fe)
C:0.12%, Mn:1.49%, P:0.013%, S:0.005%, aluminum:0.043%, N:0.041%, B:0.0029% and B steel (mass%, the remainder substantially Fe)
C, Mn, P, S, and aluminum are the same as A steel.
N:0.033%, B:0.0055% [0032] A cross section attaches a plate 3 to opening of the shaping member 2 of a hat form, and as shown in drawing 2 , as shown in drawing, said trial member 1 carries out spot welding of the flange of the shaping member 2 in 40mm pitch. The dimension unit in drawing is mm and the slash section given to the corner (two places) of the upper part of the hat formation form member 2 shows the quenching section by high-frequency induction hardening which assembled the trial member and was formed behind. Quenching conditions made the thermo-cycle time about 5 seconds, it carried out water cooling to 900 degrees C after high-frequency heating, and the organization of the quenching section was martensitic structure.
[0033] Said three impacts bending test is in the condition which added the 100kg load P to the position of symmetry of the both ends (load spacing of 500mm) of the trial member 1 respectively as the hat formation form member 2 became caudad about said trial member 1, and was horizontally held as shown in drawing 3 , and is the core of the die-length direction of the trial member 1 to a bending fixture 10.6 m/sec It is made to collide and the impact absorbed energy produced at this time is measured. Said impact absorbed energy with the laser displacement gage 11 formed in the location distant from the bending fixture 10 (a upside radius = 150mm) 200mm The variation rate (condition displayed by the two-dot chain line in drawing) of the flash when the trial member 1 and the bending fixture 10 contacted was set to 0, and the trial member 1 bent and deformed, and it asked by measuring the load which acted on the bending fixture 10 until the variation rate measured by the laser displacement gage 11 was set to 70mm. Drawing 4 is drawing having shown the relation of said variation rate and load typically, and the area of the part shown with the slash in drawing shows an absorbed energy value. In addition, the load which acted on the fixture 10 was measured by the load cell 12 in which the bending fixture 10 was attached.
[0034] The result of the above-mentioned three impacts bending test is shown in drawing 5 . From this drawing, big and rough TiN generated the steel plate with which Ti content used A steel and B steel 0.015% in the high content region of **, the absorbed energy value in three impacts bending was low, and the crack was especially accepted in the quenching section by the thing [amount / of B] using B steel of this invention ******. It turns out that the very big absorbed energy value is acquired as compared with the steel plate with which especially Ti content, on the other hand, used B steel outside the invention range with the steel plate which used A steel of this invention component range in 0.010% or less of low content region, and the outstanding shock resistance is obtained.
[0035] [Example B] The steel shown in the following table 1 was ingoted, cold rolled sheet steel (1.6mm of board thickness), an alloying hot-dip zinc-coated carbon steel sheet (1.6mm of board thickness), and hot rolled sheet steel (2.0mm of board thickness) were manufactured according to the manufacture conditions which show the slab in this table, and the mechanical property was measured. The result is collectively shown in a table 1.
[0036]
[A table 1]

試料No.	化学成分（mass %、残部：実質的にFe） C	Mn	Si	P	S	Al	N	B	Ti	その他	製造方法	熱延条件 FDT ℃	熱延条件 CT ℃	冷延率 %	焼鈍温度 ℃	合金化温度 ℃	YS MPa	TS MPa	El %	備考
1	0.12	1.45	0.03	0.012	0.008	0.034	0.0044	0.0021	0.0050	–	冷延	870	660	55	780	–	285	457	33	P
2	0.16	1.47	0.02	0.011	0.007	0.033	0.0021	0.0022	0.0040	–	めっき	870	660	55	780	690	289	443	36	P
3	0.10	0.90	0.02	0.013	0.006	0.035	0.0032	0.0030	0.0040	–	冷延	870	660	55	780	–	285	487	35	P
4	0.08	1.44	0.01	0.010	0.005	0.045	0.0040	0.0011	0.0030	–	冷延	870	660	55	780	–	283	453	36	P
5	0.13	1.88	0.04	0.013	0.012	0.041	0.0038	0.0037	0.0030	–	めっき	870	660	55	780	690	303	520	28	P
6	0.11	1.52	0.03	0.016	0.008	0.038	0.0016	0.0005	0.0030	–	めっき	870	660	55	780	690	289	448	34	P
7	0.14	0.89	0.02	0.015	0.009	0.042	0.0080	0.0038	0.0050	–	冷延	870	660	55	780	–	275	449	33	P
8	0.16	0.88	0.02	0.015	0.005	0.040	0.0068	0.0022	0.0080	–	冷延	870	660	55	780	–	273	462	33	P
9	0.12	1.43	0.03	0.011	0.008	0.033	0.0078	0.0011	0.0050	–	めっき	870	660	55	780	690	285	455	31	P
10	0.09	2.45	0.03	0.014	0.005	0.047	0.0067	0.0005	0.0040	–	熱延	890	420	–	–	–	305	494	30	P
11	0.11	1.53	0.05	0.012	0.013	0.020	0.0120	0.0027	0.0050	–	冷延	870	660	50	800	–	267	451	35	C
12	0.12	1.51	0.04	0.001	0.011	0.024	0.0110	0.0011	0.0040	–	冷延	870	660	50	800	–	270	462	34	C
13	0.10	1.49	0.02	0.010	0.005	0.044	0.0044	0.0003	0.0040	–	冷延	870	660	50	800	–	285	470	38	C
14	0.13	2.70	0.03	0.012	0.006	0.033	0.0039	0.0025	0.0030	–	冷延	870	660	50	800	–	292	482	31	C
15	0.12	1.55	0.03	0.013	0.011	0.028	0.0033	0.0028	0.0180	–	めっき	870	660	50	800	630	274	481	32	C
16	0.09	2.01	0.02	0.016	0.015	0.031	0.0021	0.0045	0.0060	–	冷延	870	660	50	800	–	280	457	33	C
17	0.06	1.53	1.00	0.011	0.006	0.027	0.0029	0.0023	0.0040	Cr:0.60	熱延	890	350	–	–	–	362	588	26	P
18	0.09	1.51	0.02	0.012	0.003	0.033	0.0025	0.0028	0.0030	Mo:0.30	熱延	890	500	–	–	–	363	455	38	P
19	0.17	1.46	0.03	0.013	0.007	0.040	0.0035	0.0022	0.0050	Ni:1.10 Cu:1.00	冷延	870	660	60	800	–	269	476	33	P
20	0.12	1.50	0.02	0.014	0.005	0.033	0.0031	0.0029	0.0050	Cr:0.30 Mo:0.20	冷延	870	660	60	800	–	277	442	35	P

(注) 備考 P：発明例、C：比較例

[0037] Moreover, the sample steel plate blank test piece was extracted, high-frequency heating of the predetermined field was carried out at 900 degrees C, heating was promptly suspended after this temperature attainment, and the microstructure was questioned, while investigating quenching and hardness distribution of the quenching section circumference and asking for the average hardness of the quenching section by cooling according to the cooling conditions shown in a table 2. Moreover, after manufacturing the three impacts bending test member and tempering on the quenching conditions of a table 2 like Example A at least at the said division, said three impacts bending test was performed, and impact absorbed energy was measured, and the crack generating situation of the bending section after a trial was observed. These results are shown in a table 2. The microstructure in a table shows the organization which occupies 50% or more at the rate of area, and the remainders are a ferrite and/or retained austenite. Moreover, the graph which arranged the effect sample No.1-13 and per 16 N and B affect hardenability is shown in drawing 6 . The figure in drawing shows "Sample No. the average hardness (Hv) of the /quenching section." Moreover, an example of the hardness distribution measurement result of the quenching section circumference is shown in drawing 7 (sample No.13) and drawing 8 R> 8 (sample No.7). In addition, the quenching section in drawing 7 and drawing 8 corresponds to the dotted-line location of the center section of the quenching field (slash field) of drawing 2 .

[0038]

[A table 2]

試料No.	焼入条件	焼入部平均硬さ(Hv)	焼入部主要ミクロ組織*	衝撃3点曲げ吸収エネルギー(J)	衝撃3点曲げ曲げ部割れ発生状況	備考
1	水冷	416	M	2476	なし	発明例
2	水冷	413	M	2458	なし	〃
3	水冷	427	M	2542	なし	〃
4	水冷	397	M	2363	なし	〃
5	水冷	429	M	2554	なし	〃
6	水冷	365	M	2173	なし	〃
7	水冷	369	M	2196	なし	〃
8	水冷	374	M	2226	なし	〃
9	水冷	338	M	2012	なし	〃
10	水冷	335	M	1994	なし	〃
11	水冷	281	M	1287	なし	比較例
12	水冷	287	M	1314	なし	〃
13	水冷	344	M	1575	あり	〃
14	水冷	435	M	1992.	なし	〃
15	水冷	427	M	1955	あり	〃
16	水冷	396	M	1813	あり	〃
17	空冷	433	B	2577	なし	発明例
18	空冷	407	B	2423	なし	〃
19	水冷	412	B	2452	なし	〃
20	空冷	425	B	2530	なし	〃

(注) * 面積率50%以上を占めるミクロ組織を表示
M：マルテンサイト、B：ベイナイト

[0039] A passage clear from a table 2 and drawing 6 , ** reaches [N] sample No.11 0.010%, in 12, the hardness of the quenching section is less than 300Hv(s), and sufficient quenching hardness is not obtained, but it turns out that a consolidation is inadequate. Moreover, the absorbed energy of these samples is also low. Since the amount of N is excessive, this is guessed because it becomes inadequate decomposing [of BN at the time of being high-frequency heating].
[0040] Moreover, from a table 2 and drawing 6 , although sample No.16 of 0.004% ** and B of B were [the hardness of the quenching section] good at less than 0.0005% of sample No.13, absorbed energy was low and the crack occurred in the bending section. Since the amount of B is excessive at sample No.16, this is Fe2 B to a grain boundary. It is because it deposited and, on the other hand, is because there were too few amounts of B and sufficient hardenability was not acquired in sample No.13. Incidentally, although average hardness is as good as 344Hv(s) a passage clear from drawing 7 , unevenness is in the hardness of the quenching section, and if hardness distribution of sample No.13 is seen, if it lengthens, in order that unevenness may arise about reinforcement and deformation may concentrate on a part with low reinforcement, what the crack produced will be conjectured. In addition, although hardness distribution of sample No.7 of the example of invention is shown in drawing 8 , in this example, the average hardness of the quenching section is 369Hv(s), and, moreover, the hardness in the quenching section is also uniform.
[0041] Moreover, from a table 2, by sample No.17-20 (example of invention) which added the improvement element in a property other than a fundamental component, since the microstructure is a bainite subject, much more improvement in absorbed energy is accepted.
[0042] [Example C] The steel shown in the following table 3 was ingoted, and cold rolled sheet steel (1.6mm of board thickness) was manufactured for the slab with hot rolling (finishing temperature of 860 degrees C, winding temperature of 550 degrees C), and cold rolling (the rate of cold-rolling of 60%, recrystallization annealing temperature of 700 degrees C). Using the sample offering steel plate extracted from this cold rolled sheet steel, as shown in drawing 9 , high-frequency induction hardening was given all over the sample offering steel plate on the

quenching conditions which send in the steel plate guide 21 to the sample offering steel plate W among the high frequency coil 22 and cooled nozzles 23 and 23 by which opposite arrangement was carried out, and show it in a table 4. A thermo-cycle time is about 3 seconds, and was promptly cooled after hardening temperature attainment.
[0043]
[A table 3]

鋼種 No.	化学成分（mass %、残部：実質的にFe）											備考
	C	Si	Mn	P	S	Al	N	B	Ti	Cr	Mo	
A	0.16	<0.02	1.60	0.010	0.005	0.035	0.003	0.0030	<0.01	<0.02	<0.02	発明鋼
B	0.13	<0.02	1.52	0.008	0.007	0.030	0.035	0.0025	<0.01	<0.02	<0.02	〃
C	0.10	<0.02	1.05	0.012	0.007	0.027	0.033	0.0033	<0.01	0.30	<0.02	〃
D	0.13	<0.02	0.95	0.010	0.006	0.033	0.004	<0.0003	<0.01	<0.02	<0.02	比較鋼
E	0.13	<0.02	2.00	0.011	0.005	0.028	0.028	<0.0003	<0.01	<0.02	<0.02	〃
F	0.16	<0.02	1.50	0.010	0.006	0.031	0.003	0.0028	<0.01	0.50	0.30	発明鋼

[0044] While extracting the test piece for tensile test from the obtained high-frequency-induction-hardening consolidation steel plate and asking for maximum stress (static TS) under low-speed **** (speed-of-testing 2 mm/sec), it asked for maximum stress (dynamic TS) under high-speed **** (speed-of-testing 10 m/sec), and asked for the static-dynamic ratio. In addition, stress attached the strain gage to both sides of a test piece, and computed it from the average load measured by this. Moreover, the organization observation piece was extracted from the high-frequency-induction-hardening consolidation steel plate, microscope observation of the trace of the old austenite grain boundary before quenching was carried out, and the diameter of average crystal grain was measured. These results of an investigation are collectively shown in a table 4. Moreover, the graph which arranged the relation between a static-dynamic ratio and the old austenite particle size is shown in drawing 10 . In addition, the tensile strength before quenching was also collectively shown in a table 4.
[0045]
[A table 4]

試料 No.	鋼種 No.	焼入前 TS Mpa	焼入温度 ℃	冷却条件	静的 TS Mpa	動的 TS Mpa	静動比	旧オーステナイト粒径 μm	備考
31	B	466	900	水冷	1250	1413	1.13	20	発明鋼
32	B	〃	800	〃	1050	1155	1.10	10	〃
33	F	456	900	空冷	1025	1148	1.12	12	〃
34	A	460	900	〃	1320	1412	1.09	18	〃
35	A	〃	800	〃	1013	1124	1.11	12	〃
36	C	455	900	〃	1033	1126	1.09	15	〃
37	C	〃	800	〃	981	1079	1.10	11	〃
38	D	444	1000	水冷	1350	1391	1.03	83	比較鋼
39	D	〃	900	〃	1180	1239	1.04	45	〃
40	D	〃	800	〃	965	1033	1.03	26	〃
41	E	480	900	〃	1350	1391	1.03	34	〃
42	E	〃	800	空冷	1250	1313	1.05	28	〃

[0046] For sample No.31-37 [drawing 10 / a table 4 and] using invention steel, the old austenite particle size is 20 micrometers. It is the following and it was guessed that a static-dynamic ratio is a high value as compared with the example of a comparison, and is excellent in an impact-absorbing property.
[0047] Furthermore, steel type A-C (invention steel) of a table 3 is used, and after cold-rolling to 1.6mm of board thickness, it is 45g/m2 in both sides at a continuation hot-dip-zincing line further. Hot dip zincing was given, the three impacts bending test member 1 was manufactured like Example A, and high-frequency induction hardening was performed at least in the said division on condition that the following table 5. A thermo-cycle time is about 3 seconds, and was

promptly cooled after hardening temperature attainment.
[0048] The existence of the galvanization layer in the quenching section of a trial member was observed after high-frequency induction hardening. Furthermore, the paint film friction test was performed in the following way, and the existence of exfoliation of the paint film formed in the quenching section was investigated. A trial member is degreased, it is immersed in phosphate processing liquid for 2 minutes at 40 degrees C after rinsing desiccation, a phosphate coat is formed in the quenching section, and they are after rinsing desiccation and about 20 micrometers of thickness. The paint film was formed by electropainting. After desiccation and 10x10mm2 The grid of 1mm pitch was put into the test area with the cutter knife, it was immersed into 240hrs pure water at 40 degrees C, and adhesive tape was stuck and torn off to the test area after desiccation, and when the number of those to which the paint film exfoliated 50% or more in the grid of 1mm angle was also one, it judged with those with exfoliation (x).
[0049]
[A table 5]

試料 No.	鋼種 No.	焼入温度 ℃	冷却条件	焼入部硬さ	めっき層 残存:○ 消失:×	塗膜剥離 なし:○ あり:×
51	B	800	〃	352	○	○
52	〃	900	〃	383	○	○
53	〃	1000	〃	413	○	○
54	A	800	空冷	310	○	○
55	〃	900	〃	337	○	○
56	〃	1100	〃	343	×	×
57	C	800	〃	302	○	○
58	〃	900	〃	321	○	○
59	〃	1100	〃	373	×	×

[0050] In what made hardening temperature 1000 degrees C or less, and performed high-frequency induction hardening from a table 5 using invention steel (57 sample No.51-55, 58), the hot-dip-zincing layer remained and excelling also in the adhesion of a paint film was confirmed.
[0051] [Example D] After ingoting the steel of the following presentation, hot-rolling the continuous casting slab to 4.0mm of board thickness (finishing temperature of 870 degrees C, winding temperature of 660 degrees C), cold-rolling to 2.0mm of board thickness (50% of rates of cold-rolling) and performing recrystallization annealing temperature at 720 degrees C in a continuous-annealing hot-dip-zincing line, hot dip zincing (the amount of plating: both sides 45 g/m2) is given at 460 degrees C, and it is 690 degree-Cx7sec succeedingly. Alloying processing was performed. The sample offering steel plate (it is 2.0tx40wx300L at mm) was extracted from the obtained alloying hot-dip zinc-coated carbon steel sheet, and the high-frequency-induction-hardening equipment of drawing 9 was used and quenched at this.
- Steel plate component (mass%, the remainder substantially Fe)
C:0.13%, Mn:1.98%, P:0.013%, S:0.012%, aluminum:0.041%, Ti<0.01%, N:0.004%, B:0.0037% [0052] Thermo-cycle times are 3sec(s). The feed rate of a steel plate was adjusted and the existence of a plating layer and Fe content in a plating layer were investigated about the sample offering steel plate which carried out water cooling after quenching with various hardening temperature so that it might become extent. The graph which arranged the relation between hardening temperature and Fe content is shown in drawing 12 . From drawing 12 , it was checked that a plating layer remains [hardening temperature] below 1000 degrees C. Moreover, it was checked that the amount of Fe(s) in a plating layer is also about 25% or less.
[0053] Next, hardening temperature was made into 700 degrees C, 800 degrees C, 900 degrees C, and 1000 degrees C, the cooling rate after heating was adjusted, and high-frequency induction hardening was performed under various thermo-cycle times. Fe content in the plating layer of the obtained steel plate is investigated, and the graph which arranged the relation between a thermo-cycle time and Fe content is shown in drawing 13 . From drawing 13 , thermo-cycle

times are 60sec(s). Below, it was checked that Fe in a plating layer has stopped to about 35% or less.
[0054] Furthermore, the corrosion spool (it is 2.0tx70wx150L at mm) was extracted from said sample offering steel plate which performed high-frequency induction hardening in various thermo-cycle times, and the corrosion test was performed. The corrosion test was carried out by measuring the maximum hole vacancy depth after 170 cycles by making the following process into 1 cycle according to the JASO automobile ingredient corrosion approach. The result is shown in drawing 14 .
- 1 cycle process ** salt water (35-degree-C, 5% of concentration) fuel-spray: — 8hr** desiccation (60-degree-C, 30% of relative humidity): — 4hr** humidity (50-degree-C, 90% of relative humidity) exposure: — the amount of Fe(s) in a plating layer from 2hr drawing 14 , if it is 35% or less The maximum hole vacancy depth is 500 micrometers. It is 200 micrometers, if it is below extent and is 25% or less. It has stopped at extent and the thing equipped with the corrosion resistance which is satisfactory practically to be was checked.
[Effect of the Invention] Since according to this invention a grain boundary is strengthened while hardenability improves by free B produced by decomposition of BN on the occasion of high-frequency heating, and preventing austenite grain growth in case it is quenching since Ti, N, and B were regulated in the specific range, the mechanical property of the quenching section becomes homogeneity and it excels not only in reinforcement but in toughness, and a static-dynamic ratio improves and the outstanding shock resistance is obtained.

[Translation done.]

TECHNICAL FIELD

[The technical field to which invention belongs] This invention relates to the steel plate which can attain high intensity-ization of a member by carrying out high-frequency induction hardening of the necessary part, a high-frequency-induction-hardening consolidation member, and its manufacture approach after processing a required configuration especially about raw material steel plates for processing, such as a member for automobiles.

[Translation done.]

PRIOR ART

[Description of the Prior Art] The property which absorbs the striking energy at the time of a collision may be required of the shaping member for automobiles which processed sheet steel by deforming, without the member breaking thoroughly at the time of an automobile collision. The reinforcing materials for striking-energy absorption are attached to the member as which such a property is required, and it is designed so that demand characteristics may be satisfied. For example, since the shocking deformation by three-point bending produces the center pillar which is the important member of an automobile side face at the time of a collision, reinforcing materials are used for the part bending deformation is expected to be.
[0003] On the other hand, for lightweight-izing of an automobile, it is desirable to omit reinforcing materials. For that, it is possible to use a high-strength steel plate as a raw material steel plate. However, a high-strength steel plate has the problem of being inferior to a moldability. Then, instead of using reinforcing materials or a high-strength steel plate in recent years, a steel plate with comparatively low reinforcement is used, it fabricates in a predetermined configuration, and the technique which gives high-frequency induction hardening and carries out a quenching consolidation after shaping is being applied to the part which needs reinforcement.
[0004] When applying this technique, it is necessary to raise the hardenability of a raw material steel plate. B addition is well used as a means which raises the hardenability of steel. Although free B in steel participates in hardenability in that case, since B is an element which is very easy to combine with N in steel, if B combines with N and generates boron nitride (BN), the quenching effectiveness of B will disappear. For this reason, adding Ti which is easy to combine with N more than N equivalent, fixing N in steel as TiN, preventing association with N and B, and securing free B from B is performed.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] Since according to this invention a grain boundary is strengthened while hardenability improves by free B produced by decomposition of BN on the occasion of high-frequency heating, and preventing austenite grain growth in case it is quenching since Ti, N, and B were regulated in the specific range, the mechanical property of the quenching section becomes homogeneity and it excels not only in reinforcement but in toughness, and a static-dynamic ratio improves and the outstanding shock resistance is obtained.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] The impact-absorbing property at the time of a collision is important for a center pillar, a bumper phosphorus force, etc. which are a member for automobiles, when attaining a consolidation with the application of a quenching consolidation to these members, it does not say that what is necessary is just to form a high degree of hardness only for a consolidation, and a crack does not occur at the time of collision deformation, but it is important for the quenching section that impact absorbed energy is large.
[0006] However, when N was fixed by Ti and B was added, it was easy to generate a crack in the quenching section, and it became clear that an impact-absorbing property did not necessarily improve. When that cause was investigated, big and rough TiN existed in the fracture surface, and that from which this TiN has caused generating of a crack was presumed. In order to generate at the time of the ingot of steel, TiN is made big and rough and distributed in a raw material. Furthermore, in heating at the time of quenching, it does not decompose but after quenching exists as it is. Therefore, it is effective to reduce the amount of Ti as much as possible to control the crack of the quenching section and raise an impact-absorbing property. However, if it does so, the improvement effectiveness in hardenability of B can also be expected no longer according to reduction of the amount of Ti.
[0007] This invention offers the steel plate for high-frequency induction hardening which was made in view of this problem, was excellent in hardenability, and was excellent in the impact-absorbing property which the quenching section moreover equipped with toughness, a high-frequency-induction-hardening consolidation member, and its manufacture approach.

[Translation done.]

MEANS

[Means for Solving the Problem] The steel plate for high-frequency induction hardening of this invention indicated to claim 1 is mass%, and consists of the remainder Fe and an unescapable impurity including less than [aluminum:0.06%], less than [Ti:0.015%], N:0.010% or less, and B:0.0005 - 0.0040% C:0.05 - 0.20%, Mn:0.3-2.5%, P:0.02% or less, and S:0.02% or less. Since Ti, N, and B were regulated to the specified quantity according to this steel plate, the improvement operation in hardenability by B, front [quenching] austenite grain growth depressant action, and the potentiation of the grain boundary are heating of a short time like high-frequency heating conjointly, moreover, even if hardening temperature is comparatively low, the quenching effectiveness can fully be demonstrated and an impact-absorbing property can be raised by improvement in toughness of the quenching section.
[0009] It is thought that the steel plate of this invention can contain any one or more sorts of Si, Cr, Mo, V, W, Cu, and nickel 1.0% or less if needed, respectively, and can raise an impact-absorbing property more by content of these elements as indicated to claim 2 besides the above fundamental component.
[0010] Moreover, it is formed with said steel plate for high-frequency induction hardening, high-frequency induction hardening is given to the part which raises reinforcement, and the high-frequency-induction-hardening consolidation member of this invention indicated to claim 3 is excellent in an impact-absorbing property.
[0011] It is formed by the hot-dip zinc-coated carbon steel sheet which makes a blank said steel plate for high-frequency induction hardening, and high-frequency induction hardening is given to the part which raises reinforcement, a plating layer comes to remain in the quenching section, and the high-frequency-induction-hardening consolidation member of this invention indicated to claim 4 is excellent in an impact-absorbing property, and, moreover, excellent also in paintwork and corrosion resistance. An alloying hot-dip zinc-coated carbon steel sheet is contained in said hot-dip zinc-coated carbon steel sheet.
[0012] The old austenite particle size before quenching observed in the quenching section in these high-frequency-induction-hardening consolidation members as indicated to claim 5 is 20 micrometers. By considering as the following A static-dynamic ratio (when the maximum stress in the case of being the high-speed deformation sigmaA and whose deformation velocity are 10 m/sec extent about the maximum stress in the case of being the low-speed deformation whose deformation velocity is 2.0 mm/sec extent is set to sigmaB in a tension test, it is static-dynamic ratio =sigmaB/sigmaA) can be raised, and the outstanding impact-absorbing property is acquired.

[0013] Moreover, the manufacture approach of the high-frequency-induction-hardening consolidation member of this invention indicated to claim 6 forms in a predetermined configuration the steel plate for high-frequency induction hardening indicated to claims 1 or 2, and gives high-frequency induction hardening to the part which raises reinforcement with Ar of three or more points, and the hardening temperature of 1000 degrees C or less. Moreover, the manufacture approaches of the high-frequency-induction-hardening consolidation member of this invention indicated to claim 7 are 60sec(s) about a thermo-cycle time until it forms in a predetermined configuration the steel plate for high-frequency induction hardening indicated to

claims 1 or 2, and is 1000 degrees C or less in three or more Ar(s) and hardening temperature, and it arrives at the part which raises reinforcement from the heating initiation in the case of quenching at hardening temperature and it is cooled by 350 degrees C after that. High-frequency induction hardening made into the following is given. since the hot-dip zinc-coated carbon steel sheet (an alloying hot-dip zinc-coated carbon steel sheet is included.) which makes a blank the steel plate for high-frequency induction hardening indicated to claims 1 or 2 or the steel plate for high-frequency induction hardening concerned in these invention is used -- shaping -- easy -- moreover, hardening temperature -- the old austenite particle size before quenching of 1000 degrees C or less which quenching of at low temperature is attained comparatively, and is observed in the quenching section -- 20 micrometers It can consider as the following and excels in an impact-absorbing property. And the deformation after quenching can also be reduced with low-temperature quenching. Furthermore, in the case of a hot-dip zinc-coated carbon steel sheet, since hardening temperature is as low as 1000 degrees C or less, if it can prevent that a galvanization layer disappears by evaporation and lengthens in case it is quenching, degradation of the paintwork by generation of an iron system oxide film can be prevented. And they are 60sec(s) about a thermo-cycle time (refer to drawing 11). Since it considers as the following, in case a hot-dip-zincing layer is quenching, too much alloying, i.e., corrosion resistance degradation by Fe atom being spread too much in a hot-dip-zincing layer, can be prevented.

[0014]

[Embodiment of the Invention] this invention person noted that BN decomposed also whenever [stoving temperature / at the time of high-frequency induction hardening]. However, in quenching by high-frequency heating, whether as compared with heat treatment usual in heating time, sufficient free B which BN fully decomposes and contributes to improvement in hardenability since it is short is securable poses a problem. As a result of investigating the hardenability and impact absorbed energy of a steel plate which ingoted the steel of various Ti and N, and the amount of B, and were manufactured, so, under Ti, N, and B of the amount of specification The quenching effectiveness by B could fully be demonstrated also with heating of a short time like high-frequency heating, and a crack did not occur at the time of the high-speed deformation at the time of a collision etc., but the knowledge of a value also with high impact absorbed energy being acquired is carried out, and it came to complete this invention.

[0015] That is, the steel plate for high-frequency induction hardening of this invention is mass%, and consists of the remainder Fe and an unescapable impurity including less than [aluminum:0.06%], less than [Ti:0.015%], N:0.010% or less, and B:0.0005 - 0.0040% C:0.05 - 0.20%, Mn:0.3-2.5%, P:0.02% or less, and S:0.02% or less.

[0016] Here, the reason for component definition of the steel plate of this invention is explained. Although it is the important element with which C:0.05 - 2.0%C determines quenching hardness, at less than 0.05%, required hardness (they are 300 or more Hvs at Vickers hardness number (load 1kgf)) is not obtained. For this reason, the minimum of the amount of C is preferably made into 0.10% 0.05%. On the other hand, since it will become easy to produce delayed fracture in the quenching section if it exceeds 2.0%, an upper limit is preferably made into 0.18% 2.0%.

[0017] Mn: It is the element which raises hardenability 0.3 to 2.5% as for Mn, and at less than 0.3%, the improvement operation in hardenability becomes [too little], and it becomes difficult to obtain required quenching hardness. For this reason, the minimum of the amount of Mn is more preferably made into 1.0% 0.5% 0.3%. On the other hand, it is easy to carry out the microsegregation of Mn at the time of casting, and after quenching is not canceled, but this segregation makes an upper limit 2.0% preferably 2.5% in order to promote lowering and delayed fracture of toughness.

[0018] In order for P:0.02%or less P as well as Mn to be the element which carries out microsegregation, to produce remarkable main segregation (segregation in a board thickness center section) if it is so good that it is few and 0.02% is exceeded, and to promote delayed fracture, an upper limit is preferably made into 0.015% 0.02%.

[0019] It is so good that there is since S:0.02%or less S combines with Mn, generates MnS, degrades the workability of a steel plate and also becomes the origin of delayed fracture, and makes an upper limit 0.015% preferably 0.02%. [little]

[0020] aluminum: Although aluminum is added as deoxidation material 0.06% or less, since the inclusion of an alumina system will increase and surface discontinuity, such as HEGE and sliver, will increase rapidly if 0.06% is exceeded, make an upper limit into 0.05% preferably 0.06%.
[0021] Since TiN big and rough in 0.015% ** comes to arise although it has the operation which controls that combine Ti:0.015%or less Ti with an N and precedence target, and B combines with N, high-frequency heating does not decompose this TiN, either but it exists during an organization, a crack comes to occur at the time of high-speed deformation a passage clear [to the after-mentioned] from an example. For this reason, it may be 0.010% or less more preferably 0.012% or less 0.015% or less.
[0022] In order for N to combine with B N:0.010% or less and to decrease the free amount of B in steel, little direction is good, but since too much reduction raises a manufacturing cost with the difficulty on steel manufacture, it is good to make a minimum into 0.0010% preferably. On the other hand, since the improvement effect of the hardenability by B can be demonstrated no longer if 0.010% is exceeded, an upper limit is preferably made into 0.008% 0.010%.
[0023] B:0.0005 - 0.0040%B is an important element with which hardenability is made to improve and quenching organization sufficient also at low temperature is obtained. Moreover, when it heats to hardening temperature, i.e., austenitizing temperature, it is the element which B depositing in the austenite grain boundary, and there being low-temperature quenching being possible and an operation which controls grain growth conjointly, being able to attain detailed-ization of a quenching organization, and raising a static-dynamic ratio by this cuts. The deposit to said grain boundary is also the element which can raise the toughness of a low-temperature transformation organization further again in order to raise the reinforcement of a grain boundary. Since the amount [with the effective amount of B] of B in the case of quenching at less than 0.0005% cannot be secured but the above-mentioned operation becomes [too little], a minimum is more preferably made into 0.0025% 0.0010% 0.0005%. On the other hand, it is Fe2 B when 0.0040% is exceeded. (nitriding iron) It comes to generate, and this serves as an origin of the crack at the time of high-speed deformation, and reduces the absorbed energy at the time of impact bending deformation on the contrary. For this reason, an upper limit is preferably made into 0.0035% 0.0040%.
[0024] Although the steel plate of this invention consists of the above fundamental component, Remainder Fe, and unescapable impurity, content of other elements cannot be barred in the range which does not spoil the operation effectiveness of said fundamental component, and the element which raises the property of a steel plate more further can be made to contain. As such an element, any one or more sorts of Si, Cr, Mo, V, W, Cu, and nickel can be contained 1.0% or less, respectively.
[0025] These elements bainite-ize the microstructure of the quenching section, and raise ductility, while contributing to prevention of crack generating, required quenching reinforcement can be secured, and Cu and nickel are further contributed also to an improvement of a delayed fracture-proof property. For demonstrating this operation effectively, 0.05% or more of content is respectively desirable. If it adds too much, in order, as for Si, Cr, Mo, V, and W, for chemical conversion nature to deteriorate and for hot tearing and the surface crack resulting from a scale to produce Cu and nickel on the other hand, an upper limit is respectively made into 0.60% preferably 1.0%. In addition, a microstructure does not necessarily need to be bainite single phase and a ferrite, carbide, etc. may be contained. Moreover, these elements cannot be used as the basic element for a hardenability improvement. The reason is because chemical conversion nature deteriorates, or quenching arises at the time of steel plate manufacture and reservation of the workability of the raw material steel plate before a high-frequency-induction-hardening consolidation becomes difficult, when hardenability is improved by these elements.
[0026] Said steel plate for high-frequency induction hardening ingots the steel of a predetermined component, and is manufactured hot rolling or by cold-rolling further with a conventional method. The steel plate organization which gave hot dip zincing further after hot-rolling, cold-rolling, or cold-rolling is a ferrite and a pearlite organization, since the tensile strength in front of high-frequency induction hardening is below 500MPa extent, it is easy press forming and it can fabricate it easily in a predetermined member configuration. The high-

frequency-induction-hardening consolidation member of this invention is obtained after shaping by performing RF quenching to the part (all the fields of a member being included.) whose reinforcement wants to improve. In addition, the cooling approach after quenching can take proper approaches, such as contact of water cooling, Myst cooling, air-water cooling, air cooling (forced-air cooling is included.), and cooling metal mold, according to board thickness.

[0027] Although hardening temperature is 1000-degree-C super-**(ed) in the carbon steel plate which has C content specified by this invention in order to usually enlarge austenite particle size before quenching in order to obtain martensite with quenching, and to raise hardenability by this this invention — the improvement operation in hardenability of B — hardening temperature — comparatively — low temperature — it can set up — 1000 degrees C or less — desirable — 950 degrees C or less — more — desirable — 900 degrees C or less — it can carry out at low temperature comparatively. It is 20 micrometers about the old austenite particle size conjointly observed after quenching by setting hardening temperature as such temperature with the austenite grain growth depressant action by the grain boundary deposit of B. It can consider as the following. It is 20 micrometers about the old austenite particle size. It is 15 micrometers preferably hereafter. If the static-dynamic ratio of the quenching section can be raised and is lengthened by considering as the following, the impact-absorbing property of a high-frequency-induction-hardening consolidation member can be raised.

[0028] Drawing 1 is a stress distorted diagram for explaining the relation between a static-dynamic ratio and impact absorbed energy, and, for A in drawing, speeds of testing are 2 mm/sec. It is stress **** in the case of being low-speed **** which is extent, and, for B, speeds of testing are 10 m/sec. It is stress **** of high-speed **** supposing the time of the collision which is extent. the ratio of maximum stress sigmaB of B [as opposed to maximum stress sigma/ of A / A in a static-dynamic ratio] — it is expressed with sigma B/sigma A. On the other hand, the field (field shown in the slash section about stress ****A) surrounded by stress **** shows the impact absorbed energy at the time of deformation. The impact absorbed energy at the time of high-speed deformation becomes large, so that from drawing and a static-dynamic ratio is large. It becomes the thing equipped with the impact-absorbing property which the impact-absorbing static-dynamic ratio also improved and was excellent while reinforcement improved by high-frequency induction hardening the passage clear from the below-mentioned example in the case of this invention steel plate, although it could not necessarily say that yes, an impact-absorbing property became advantageous only by a static-dynamic ratio tending to approach 1, so that reinforcement becomes large with a high-tensile-steel plate, such as a ten, and raising steel plate reinforcement.

[0029] The steel plate of this invention can perform hot-dip-zincing processing after cold rolling, and can use it as a hot-dip zinc-coated carbon steel sheet. Of course, alloying heat treatment is performed after hot dip zincing, and it is good for it also as an alloying hot-dip zinc-coated carbon steel sheet.

[0030] The high-frequency-induction-hardening consolidation member of this invention is obtained also by carrying out press forming to a predetermined configuration, and giving high-frequency induction hardening to the part which should be strengthened using such a hot-dip zinc-coated carbon steel sheet. In this case, when hardening temperature is too high, in case it is quenching, zinc evaporates, a galvanization layer disappears, and there is a possibility that an oxide film may be further formed on the surface of a steel plate. If a galvanization layer disappears and an oxide film is formed, when painting a member front face, if the phosphoric acid salt coat which is the substrate of paint stops being able to adhere easily and lengthens, paint film adhesion deteriorates. In this invention, disappearance of a galvanization layer can be prevented according to an operation of B by being able to make hardening temperature low and making more preferably 1000 degrees C or less of 950 degrees C or less of hardening temperature into 900 degrees C or less, and good paint adhesion can also be secured. Furthermore, they are 60sec(s) about a thermo-cycle time (refer to drawing 11) until it reaches hardening temperature from the heating initiation in the case of quenching and is cooled by 350 degrees C after that. They are 30sec(s) preferably hereafter. They are 10sec(s) more preferably hereafter. Since too much alloying of a hot-dip-zincing layer can be controlled by considering as

the following, corrosion resistance degradation of a hot-dip-zincing layer can be prevented.
Hereafter, although an example explains this invention still more concretely, this invention is not restrictively interpreted according to this example.

[Translation done.]

EXAMPLE

[Example] [Example A] The steel which added Ti of various rates to base steel is ingoted by using following A steel and B steel as the base. The slab is hot-rolled with a conventional method (finishing temperature of 870 degrees C, winding temperature of 650 degrees C). It cold-rolled (the rate of cold-rolling of 55%, recrystallization annealing temperature of 720 degrees C), cold rolled sheet steel of 1.6mm of board thickness was manufactured, the three impacts bending test member shown in drawing 2 was manufactured, and impact absorbed energy was measured by the three impacts bending test.
- A steel (mass%, the remainder substantially Fe)
C:0.12%, Mn:1.49%, P:0.013%, S:0.005%, aluminum:0.043%, N:0.041%, B:0.0029% and B steel (mass%, the remainder substantially Fe)
C, Mn, P, S, and aluminum are the same as A steel.
N:0.033%, B:0.0055% [0032] A cross section attaches a plate 3 to opening of the shaping member 2 of a hat form, and as shown in drawing 2 , as shown in drawing, said trial member 1 carries out spot welding of the flange of the shaping member 2 in 40mm pitch. The dimension unit in drawing is mm and the slash section given to the corner (two places) of the upper part of the hat formation form member 2 shows the quenching section by high-frequency induction hardening which assembled the trial member and was formed behind. Quenching conditions made the thermo-cycle time about 5 seconds, it carried out water cooling to 900 degrees C after high-frequency heating, and the organization of the quenching section was martensitic structure.
[0033] Said three impacts bending test is in the condition which added the 100kg load P to the position of symmetry of the both ends (load spacing of 500mm) of the trial member 1 respectively as the hat formation form member 2 became caudad about said trial member 1, and was horizontally held as shown in drawing 3 , and is the core of the die-length direction of the trial member 1 to a bending fixture 10.6 m/sec It is made to collide and the impact absorbed energy produced at this time is measured. Said impact absorbed energy with the laser displacement gage 11 formed in the location distant from the bending fixture 10 (a upside radius = 150mm) 200mm The variation rate (condition displayed by the two-dot chain line in drawing) of the flash when the trial member 1 and the bending fixture 10 contacted was set to 0, and the trial member 1 bent and deformed, and it asked by measuring the load which acted on the bending fixture 10 until the variation rate measured by the laser displacement gage 11 was set to 70mm. Drawing 4 is drawing having shown the relation of said variation rate and load typically, and the area of the part shown with the slash in drawing shows an absorbed energy value. In addition, the load which acted on the fixture 10 was measured by the load cell 12 in which the bending fixture 10 was attached.
[0034] The result of the above-mentioned three impacts bending test is shown in drawing 5 . From this drawing, big and rough TiN generated the steel plate with which Ti content used A steel and B steel 0.015% in the high content region of **, the absorbed energy value in three impacts bending was low, and the crack was especially accepted in the quenching section by the thing [amount / of B] using B steel of this invention ******. It turns out that the very big absorbed energy value is acquired as compared with the steel plate with which especially Ti content, on the other hand, used B steel outside the invention range with the steel plate which

used A steel of this invention component range in 0.010% or less of low content region, and the outstanding shock resistance is obtained.
[0035] [Example B] The steel shown in the following table 1 was ingoted, cold rolled sheet steel (1.6mm of board thickness), an alloying hot-dip zinc-coated carbon steel sheet (1.6mm of board thickness), and hot rolled sheet steel (2.0mm of board thickness) were manufactured according to the manufacture conditions which show the slab in this table, and the mechanical property was measured. The result is collectively shown in a table 1.
[0036]
[A table 1]

試料No.	化学成分（mass %、残部：実質的にFe）										製造方法	熱延条件		冷延率	焼鈍温度	合金化温度	YS	TS	El	備考
	C	Mn	Si	P	S	Al	N	B	Ti	その他		FDT ℃	CT ℃	%	℃	℃	MPa	MPa	%	
1	0.12	1.45	0.03	0.012	0.008	0.034	0.0044	0.0021	0.0050	–	冷延	870	660	55	780	–	285	457	33	P
2	0.16	1.47	0.02	0.011	0.007	0.033	0.0021	0.0022	0.0040	–	めっき	870	660	55	780	600	289	443	36	P
3	0.10	0.98	0.02	0.013	0.006	0.035	0.0032	0.0030	0.0040	–	冷延	870	660	55	780	–	285	487	35	P
4	0.08	1.44	0.01	0.010	0.005	0.045	0.0040	0.0011	0.0038	–	冷延	870	660	55	780	–	283	453	36	P
5	0.13	1.98	0.04	0.013	0.012	0.041	0.0038	0.0037	0.0030	–	めっき	870	660	55	780	690	303	520	28	P
6	0.11	1.52	0.03	0.016	0.008	0.036	0.0010	0.0005	0.0030	–	めっき	870	660	55	780	690	289	448	34	P
7	0.14	0.89	0.02	0.015	0.009	0.042	0.0080	0.0038	0.0050	–	冷延	870	660	55	780	–	275	449	33	P
8	0.16	0.88	0.02	0.016	0.005	0.040	0.0068	0.0022	0.0080	–	冷延	870	660	55	780	–	273	462	33	P
9	0.12	1.43	0.03	0.011	0.008	0.033	0.0078	0.0011	0.0060	–	めっき	870	660	55	780	690	285	455	31	P
10	0.09	2.45	0.03	0.014	0.005	0.047	0.0067	0.0005	0.0040	–	熱延	890	430	–	–	–	305	494	30	P
11	0.11	1.53	0.05	0.012	0.013	0.029	0.0120	0.0027	0.0050	–	冷延	870	660	50	800	–	267	451	35	C
12	0.12	1.51	0.04	0.001	0.011	0.024	0.0110	0.0011	0.0040	–	冷延	870	660	50	800	–	270	462	34	C
13	0.10	1.49	0.02	0.010	0.005	0.044	0.0044	0.0003	0.0040	–	冷延	870	660	50	800	–	285	470	36	C
14	0.13	2.70	0.03	0.012	0.006	0.033	0.0039	0.0025	0.0030	–	冷延	870	660	50	800	–	292	482	31	C
15	0.12	1.55	0.03	0.013	0.011	0.028	0.0033	0.0028	0.0180	–	めっき	870	660	50	800	690	274	481	32	C
16	0.09	2.01	0.02	0.016	0.015	0.031	0.0021	0.0045	0.0060	–	冷延	870	660	50	800	–	280	457	33	C
17	0.06	1.53	1.00	0.011	0.006	0.027	0.0029	0.0023	0.0040	Cr:0.50	熱延	890	350	–	–	–	362	588	26	P
18	0.09	1.51	0.02	0.012	0.003	0.033	0.0025	0.0028	0.0030	Mo:0.30	熱延	890	500	–	–	–	363	455	30	P
19	0.17	1.46	0.03	0.013	0.007	0.049	0.0035	0.0022	0.0050	Ni:1.10 Cu:1.00	冷延	870	660	60	800	–	269	476	33	P
20	0.12	1.50	0.02	0.014	0.005	0.033	0.0031	0.0029	0.0050	Cr:0.30 Mo:0.20	冷延	870	660	60	800	–	277	442	35	P

(注) 備考 P：発明例、C：比較例

[0037] Moreover, the sample steel plate blank test piece was extracted, high-frequency heating of the predetermined field was carried out at 900 degrees C, heating was promptly suspended after this temperature attainment, and the microstructure was questioned, while investigating quenching and hardness distribution of the quenching section circumference and asking for the average hardness of the quenching section by cooling according to the cooling conditions shown in a table 2. Moreover, after manufacturing the three impacts bending test member and tempering on the quenching conditions of a table 2 like Example A at least at the said division, said three impacts bending test was performed, and impact absorbed energy was measured, and the crack generating situation of the bending section after a trial was observed. These results are shown in a table 2. The microstructure in a table shows the organization which occupies 50% or more at the rate of area, and the remainders are a ferrite and/or retained austenite. Moreover, the graph which arranged the effect sample No.1-13 and per 16 N and B affect hardenability is shown in drawing 6 . The figure in drawing shows "Sample No. the average hardness (Hv) of the /quenching section." Moreover, an example of the hardness distribution measurement result of the quenching section circumference is shown in drawing 7 (sample No.13) and drawing 8 R> 8 (sample No.7). In addition, the quenching section in drawing 7 and drawing 8 corresponds to the dotted-line location of the center section of the quenching field (slash field) of drawing 2 .
[0038]
[A table 2]

試料No.	焼入条件	焼入部平均硬さ(Hv)	焼入部主要ミクロ組織*	衝撃3点曲げ吸収エネルギー(J)	衝撃3点曲げ曲げ部割れ発生状況	備考
1	水冷	416	M	2476	なし	発明例
2	水冷	413	M	2456	なし	〃
3	水冷	427	M	2542	なし	〃
4	水冷	397	M	2363	なし	〃
5	水冷	429	M	2554	なし	〃
6	水冷	365	M	2173	なし	〃
7	水冷	369	M	2196	なし	〃
8	水冷	374	M	2226	なし	〃
9	水冷	338	M	2012	なし	〃
10	水冷	335	M	1994	なし	〃
11	水冷	281	M	1287	なし	比較例
12	水冷	287	M	1314	なし	〃
13	水冷	344	M	1575	あり	〃
14	水冷	435	M	1992.	なし	〃
15	水冷	427	M	1955	あり	〃
16	水冷	396	M	1813	あり	〃
17	空冷	433	B	2577	なし	発明例
18	空冷	407	B	2423	なし	〃
19	水冷	412	B	2452	なし	〃
20	空冷	425	B	2530	なし	〃

(注) * 面積率50%以上を占めるミクロ組織を表示
M：マルテンサイト、B：ベイナイト

[0039] A passage clear from a table 2 and drawing 6 , ** reaches [N] sample No.11 0.010%, in 12, the hardness of the quenching section is less than 300Hv(s), and sufficient quenching hardness is not obtained, but it turns out that a consolidation is inadequate. Moreover, the absorbed energy of these samples is also low. Since the amount of N is excessive, this is guessed because it becomes inadequate decomposing [of BN at the time of being high-frequency heating].
[0040] Moreover, from a table 2 and drawing 6 , although sample No.16 of 0.004% ** and B of B were [the hardness of the quenching section] good at less than 0.0005% of sample No.13, absorbed energy was low and the crack occurred in the bending section. Since the amount of B is excessive at sample No.16, this is Fe2 B to a grain boundary. It is because it deposited and, on the other hand, is because there were too few amounts of B and sufficient hardenability was not acquired in sample No.13. Incidentally, although average hardness is as good as 344Hv(s) a passage clear from drawing 7 , unevenness is in the hardness of the quenching section, and if hardness distribution of sample No.13 is seen, if it lengthens, in order that unevenness may arise about reinforcement and deformation may concentrate on a part with low reinforcement, what the crack produced will be conjectured. In addition, although hardness distribution of sample No.7 of the example of invention is shown in drawing 8 , in this example, the average hardness of the quenching section is 369Hv(s), and, moreover, the hardness in the quenching section is also uniform.
[0041] Moreover, from a table 2, by sample No.17-20 (example of invention) which added the improvement element in a property other than a fundamental component, since the microstructure is a bainite subject, much more improvement in absorbed energy is accepted.
[0042] [Example C] The steel shown in the following table 3 was ingoted, and cold rolled sheet steel (1.6mm of board thickness) was manufactured for the slab with hot rolling (finishing temperature of 860 degrees C, winding temperature of 550 degrees C), and cold rolling (the rate of cold-rolling of 60%, recrystallization annealing temperature of 700 degrees C). Using the sample offering steel plate extracted from this cold rolled sheet steel, as shown in drawing 9 , high-frequency induction hardening was given all over the sample offering steel plate on the

quenching conditions which send in the steel plate guide 21 to the sample offering steel plate W among the high frequency coil 22 and cooled nozzles 23 and 23 by which opposite arrangement was carried out, and show it in a table 4. A thermo-cycle time is about 3 seconds, and was promptly cooled after hardening temperature attainment.
[0043]
[A table 3]

鋼種No.	化学成分（mass %、残部：実質的にFe）											備考
	C	Si	Mn	P	S	Al	N	B	Ti	Cr	Mo	
A	0.16	<0.02	1.60	0.010	0.005	0.035	0.003	0.0030	<0.01	<0.02	<0.02	発明鋼
B	0.13	<0.02	1.52	0.008	0.007	0.030	0.035	0.0025	<0.01	<0.02	<0.02	〃
C	0.10	<0.02	1.05	0.012	0.007	0.027	0.033	0.0033	<0.01	0.30	<0.02	〃
D	0.13	<0.02	0.95	0.010	0.006	0.033	0.004	<0.0003	<0.01	<0.02	<0.02	比較鋼
E	0.13	<0.02	2.00	0.011	0.005	0.028	0.028	<0.0003	<0.01	<0.02	<0.02	〃
F	0.16	<0.02	1.50	0.010	0.006	0.031	0.003	0.0028	<0.01	0.50	0.30	発明鋼

[0044] While extracting the test piece for tensile test from the obtained high-frequency-induction-hardening consolidation steel plate and asking for maximum stress (static TS) under low-speed **** (speed-of-testing 2 mm/sec), it asked for maximum stress (dynamic TS) under high-speed **** (speed-of-testing 10 m/sec), and asked for the static-dynamic ratio. In addition, stress attached the strain gage to both sides of a test piece, and computed it from the average load measured by this. Moreover, the organization observation piece was extracted from the high-frequency-induction-hardening consolidation steel plate, microscope observation of the trace of the old austenite grain boundary before quenching was carried out, and the diameter of average crystal grain was measured. These results of an investigation are collectively shown in a table 4. Moreover, the graph which arranged the relation between a static-dynamic ratio and the old austenite particle size is shown in drawing 10 . In addition, the tensile strength before quenching was also collectively shown in a table 4.
[0045]
[A table 4]

試料No.	鋼種No.	焼入前TS Mpa	焼入温度 ℃	冷却条件	静的TS Mpa	動的TS Mpa	静動比	旧オーステナイト粒径 μm	備考
31	B	466	900	水冷	1250	1413	1.13	20	発明鋼
32	B	〃	800	〃	1050	1155	1.10	10	〃
33	F	456	900	空冷	1025	1148	1.12	12	〃
34	A	460	900	〃	1320	1412	1.09	18	〃
35	A	〃	800	〃	1013	1124	1.11	12	〃
36	C	455	900	〃	1033	1126	1.09	15	〃
37	C	〃	800	〃	981	1079	1.10	11	〃
38	D	444	1000	水冷	1350	1391	1.03	83	比較鋼
39	D	〃	900	〃	1180	1239	1.04	45	〃
40	D	〃	800	〃	965	1033	1.03	26	〃
41	E	480	900	〃	1350	1391	1.03	34	〃
42	E	〃	800	空冷	1250	1313	1.05	28	〃

[0046] For sample No.31-37 [drawing 10 / a table 4 and] using invention steel, the old austenite particle size is 20 micrometers. It is the following and it was guessed that a static-dynamic ratio is a high value as compared with the example of a comparison, and is excellent in an impact-absorbing property.
[0047] Furthermore, steel type A-C (invention steel) of a table 3 is used, and after cold-rolling to 1.6mm of board thickness, it is 45g/m2 in both sides at a continuation hot-dip-zincing line further. Hot dip zincing was given, the three impacts bending test member 1 was manufactured like Example A, and high-frequency induction hardening was performed at least in the said division on condition that the following table 5. A thermo-cycle time is about 3 seconds, and was

promptly cooled after hardening temperature attainment.
[0048] The existence of the galvanization layer in the quenching section of a trial member was observed after high-frequency induction hardening. Furthermore, the paint film friction test was performed in the following way, and the existence of exfoliation of the paint film formed in the quenching section was investigated. A trial member is degreased, it is immersed in phosphate processing liquid for 2 minutes at 40 degrees C after rinsing desiccation, a phosphate coat is formed in the quenching section, and they are after rinsing desiccation and about 20 micrometers of thickness. The paint film was formed by electropainting. After desiccation and 10x10mm2 The grid of 1mm pitch was put into the test area with the cutter knife, it was immersed into 240hrs pure water at 40 degrees C, and adhesive tape was stuck and torn off to the test area after desiccation, and when the number of those to which the paint film exfoliated 50% or more in the grid of 1mm angle was also one, it judged with those with exfoliation (x).
[0049]
[A table 5]

試料 No.	鋼種 No.	焼入温度 ℃	冷却条件	焼入部硬さ	めっき層 残存:○ 消失:×	塗膜剥離 なし:○ あり:×
51	B	800	〃	352	○	○
52	〃	900	〃	383	○	○
53	〃	1000	〃	413	○	○
54	A	800	空冷	310	○	○
55	〃	900	〃	337	○	○
56	〃	<u>1100</u>	〃	343	×	×
57	C	800	〃	302	○	○
58	〃	900	〃	321	○	○
59	〃	<u>1100</u>	〃	373	×	×

[0050] In what made hardening temperature 1000 degrees C or less, and performed high-frequency induction hardening from a table 5 using invention steel (57 sample No.51-55, 58), the hot-dip-zincing layer remained and excelling also in the adhesion of a paint film was confirmed.
[0051] [Example D] After ingoting the steel of the following presentation, hot-rolling the continuous casting slab to 4.0mm of board thickness (finishing temperature of 870 degrees C, winding temperature of 660 degrees C), cold-rolling to 2.0mm of board thickness (50% of rates of cold-rolling) and performing recrystallization annealing temperature at 720 degrees C in a continuous-annealing hot-dip-zincing line, hot dip zincing (the amount of plating: both sides 45 g/m2) is given at 460 degrees C, and it is 690 degree-Cx7sec succeedingly. Alloying processing was performed. The sample offering steel plate (it is 2.0tx40wx300L at mm) was extracted from the obtained alloying hot-dip zinc-coated carbon steel sheet, and the high-frequency-induction-hardening equipment of drawing 9 was used and quenched at this.
- Steel plate component (mass%, the remainder substantially Fe)
C:0.13%, Mn:1.98%, P:0.013%, S:0.012%, aluminum:0.041%, Ti<0.01%, N:0.004%, B:0.0037% [0052] Thermo-cycle times are 3sec(s). The feed rate of a steel plate was adjusted and the existence of a plating layer and Fe content in a plating layer were investigated about the sample offering steel plate which carried out water cooling after quenching with various hardening temperature so that it might become extent. The graph which arranged the relation between hardening temperature and Fe content is shown in drawing 12 . From drawing 12 , it was checked that a plating layer remains [hardening temperature] below 1000 degrees C. Moreover, it was checked that the amount of Fe(s) in a plating layer is also about 25% or less.
[0053] Next, hardening temperature was made into 700 degrees C, 800 degrees C, 900 degrees C, and 1000 degrees C, the cooling rate after heating was adjusted, and high-frequency induction hardening was performed under various thermo-cycle times. Fe content in the plating layer of the obtained steel plate is investigated, and the graph which arranged the relation between a thermo-cycle time and Fe content is shown in drawing 13 . From drawing 13 , thermo-cycle

times are 60sec(s). Below, it was checked that Fe in a plating layer has stopped to about 35% or less.

[0054] Furthermore, the corrosion spool (it is 2.0tx70wx150L at mm) was extracted from said sample offering steel plate which performed high-frequency induction hardening in various thermo-cycle times, and the corrosion test was performed. The corrosion test was carried out by measuring the maximum hole vacancy depth after 170 cycles by making the following process into 1 cycle according to the JASO automobile ingredient corrosion approach. The result is shown in drawing 14 .

- 1 cycle process ** salt water (35-degree-C, 5% of concentration) fuel-spray: -- 8hr** desiccation (60-degree-C, 30% of relative humidity): -- 4hr** humidity (50-degree-C, 90% of relative humidity) exposure: -- the amount of Fe(s) in a plating layer from 2hr drawing 14 , if it is 35% or less The maximum hole vacancy depth is 500 micrometers. It is 200 micrometers, if it is below extent and is 25% or less. It has stopped at extent and the thing equipped with the corrosion resistance which is satisfactory practically to be was checked.

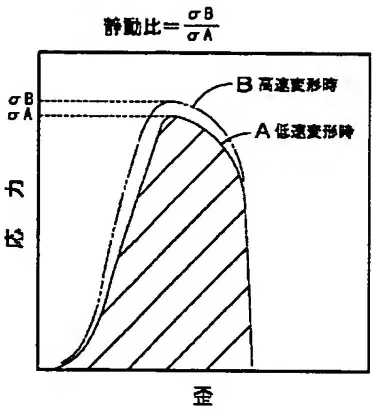
[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The stress distorted diagram in B is shown at the time of A and high-speed deformation at the time of low-speed deformation.
[Drawing 2] It is the perspective view of the trial member used for the three impacts bending test.
[Drawing 3] It is a three impacts bending test point explanatory view.
[Drawing 4] It is the displacement-load diagram showing a three impacts bending test result typically.
[Drawing 5] It is the graph which shows the relation of the amount of Ti and three impacts bending absorbed energy concerning Example A.
[Drawing 6] The amount of N concerning Example B and the amount of B are the graphs which show the effect done to the hardness of the quenching section.
[Drawing 7] It is the graph which shows the hardness distribution near [of sample No.13] the quenching section of Example B.
[Drawing 8] It is the graph which shows the hardness distribution near [of sample No.7] the quenching section of Example B.
[Drawing 9] It is the conceptual diagram showing the quenching point of the steel plate in Example C.
[Drawing 10] It is drawing showing the relation of the static-dynamic ratio and the old austenite particle size in Example C.
[Drawing 11] It is the explanatory view of the thermo-cycle time in high-frequency induction hardening.
[Drawing 12] It is the graph which shows the relation between the hardening temperature in Example D, and Fe content in a plating layer.
[Drawing 13] It is the graph which shows the relation between the thermo-cycle time in Example D, and Fe content in a plating layer.
[Drawing 14] It is the graph which shows the relation between Fe content in the plating layer in Example D, and the maximum hole vacancy depth in a corrosion test.

[Translation done.]

Drawing selection drawing 1



[Translation done.]

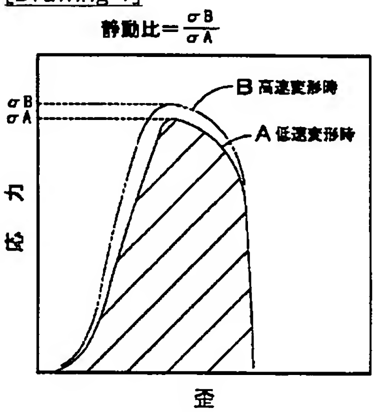
* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

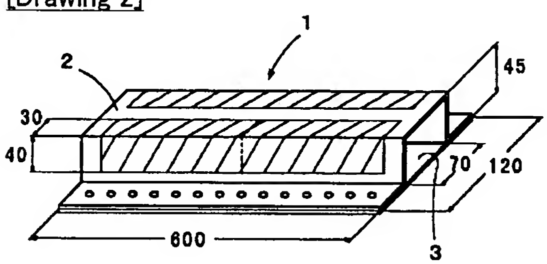
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

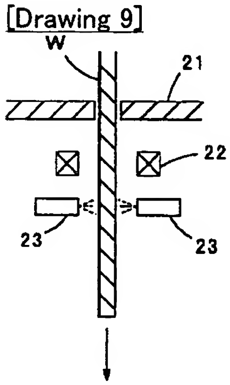
[Drawing 1]



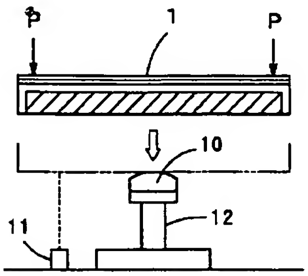
[Drawing 2]



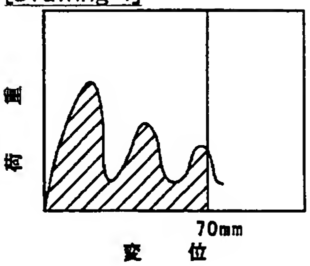
[Drawing 9]



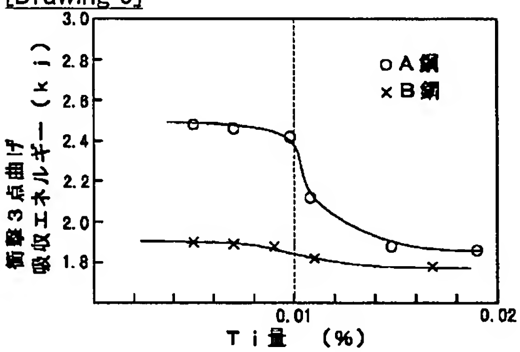
[Drawing 3]



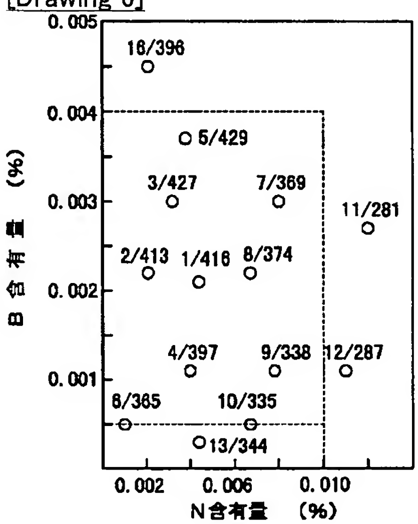
[Drawing 4]



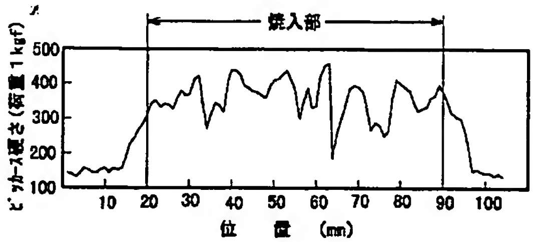
[Drawing 5]



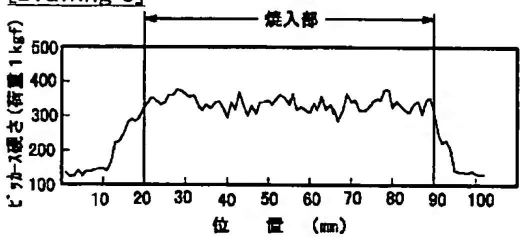
[Drawing 6]



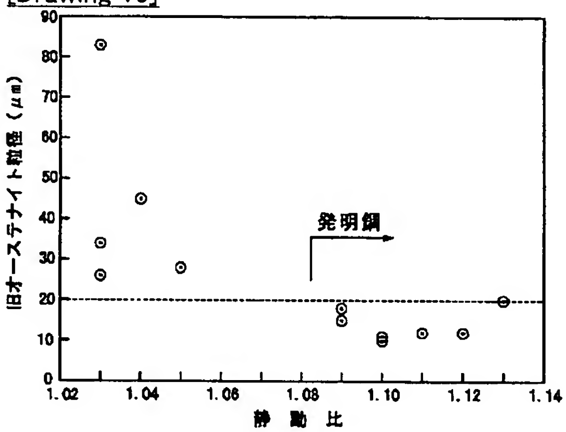
[Drawing 7]



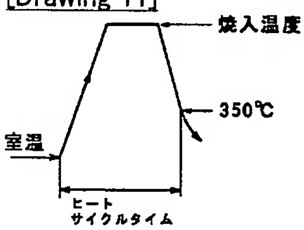
[Drawing 8]



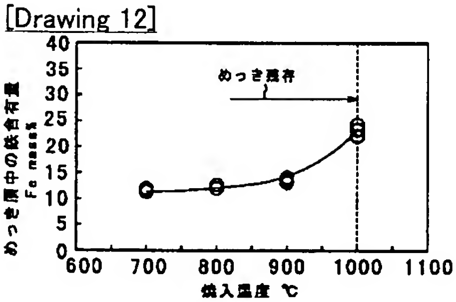
[Drawing 10]



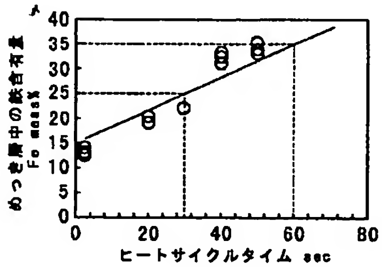
[Drawing 11]



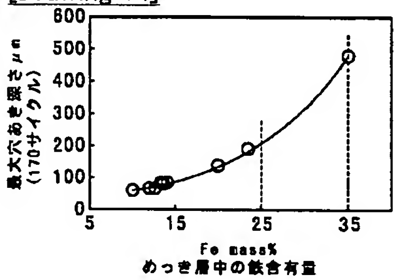
[Drawing 12]



[Drawing 13]



[Drawing 14]



[Translation done.]